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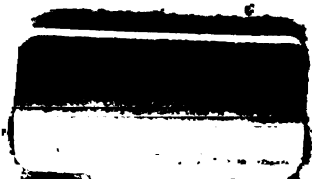
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THE
CHEMISTRY OF THE ARTS;

BEING
: A PRACTICAL DISPLAY

OF THE
ARTS AND MANUFACTURES

WHICH DEPEND
ON CHEMICAL PRINCIPLES.

With Numerous Engravings.

ON THE BASIS OF
GRAY'S OPERATIVE CHEMIST,

ADAPTED TO THE UNITED STATES;

WITH
**TREATISES ON CALICO PRINTING, BLEACHING,
AND OTHER LARGE ADDITIONS.**

BY ARTHUR L. PORTER,
LATE PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF VERMONT.

VOL. II.

Philadelphia:
CAREY & LEA.
1830.

Fig. 118, represents the whole apparatus of this manufacture, in which four tools are necessary; *a*, an iron hammer with a rectangular head, a handle seven or eight inches long, and not exceeding two pounds in weight; *e*, is the head of this instrument. *B*, a hammer of well hardened steel, with two points, a handle seven inches long, and from ten to sixteen ounces in weight; the handle must pass through in such a manner that the two points may be nearer the hand of the workman than the centre of gravity of the mass; the head of this hammer is represented at *f*. *C*, a round hammer, like a solid wheel, or the section of a cylinder, as shown at *g*, two inches and a quarter in diameter, and not exceeding twelve ounces in weight; it is made of steel, not hardened, and has a handle six inches long, which passes through a square hole in the centre. *D*, is a chisel, tapering and bevelled at both ends. It should be made of steel, not hardened, and six, seven, or eight inches long, and two inches wide; this is set on a wooden block, which is also used as a bench for the workman. Besides these tools, a file is necessary for restoring the edge of the chisel.

The workman seated on the ground, places the nodule of flint on his left thigh, and applies slight strokes with the square hammer, to divide it into smaller pieces of about a pound and a half each, with broad surfaces and almost even fracture.

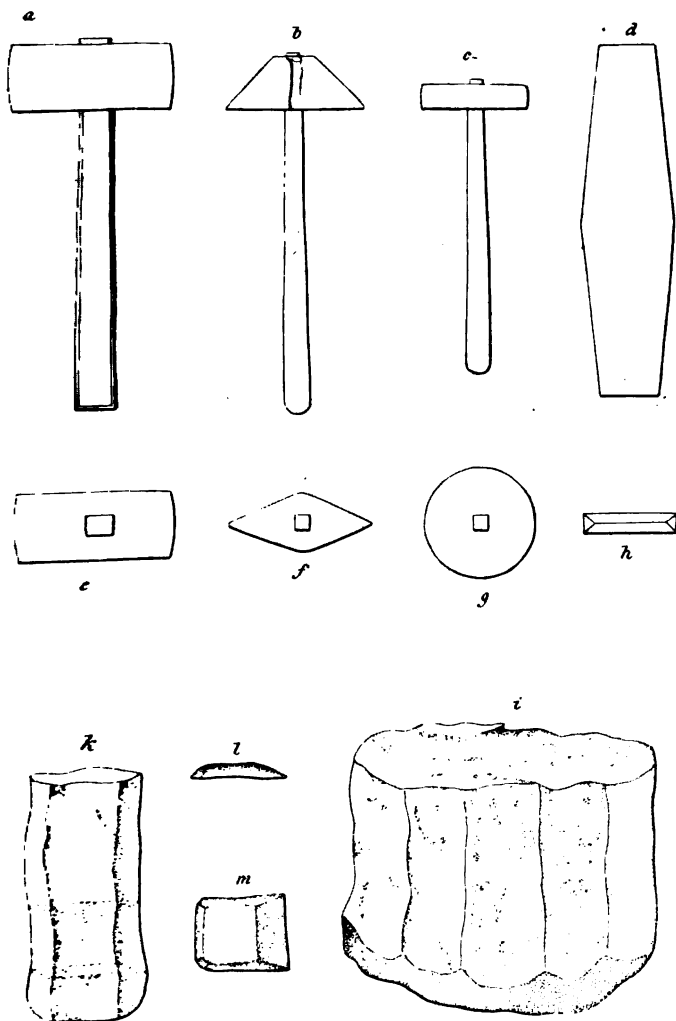
He then holds the piece of flint in his left hand, not supported, and strikes with the pointed hammer, *b*, on the edges of the great planes produced by the first breaking, by which means the white coating of the flint is removed in the form of small scales, and the mass of the flint itself laid bare in the manner represented, at *i*. After which he continues to chip off similar scaly portions from the pure mass of the flint. These scaly portions are nearly one inch and a half wide, two inches and a half long; and their thickness in the middle is about one-sixteenth of an inch. They are slightly convex below, and consequently leave in the part of the flint from which they were separated, a space slightly concave, longitudinally bordered by two rather projecting straight lines, or ridges, as at *k*. These ridges, produced by the separation of the first scales, must naturally constitute nearly the middle of the subsequent piece; and such scales alone as have their ridges thus placed in the middle are fit to be made into gun flints. In this manner the workman continues to split or chip the mass of flint in various directions, until the defects usually found in the interior render it impossible to make the fracture required, or until the piece is reduced too much to receive the blows by which the flint is divided.

Five different parts may be distinguished in a gun flint. 1. The sloping facet, or level part which is impelled against the hammer of the lock of the gun. Its width should be from two to three-twelfths of an inch; if it were broader it would be too liable to break: and if more obtuse the scintillation would be less brisk. 2. The sides or lateral ridges, which are always rather irregular. 3. The back, or the part opposite the tapering edge: this is the thickest part of the flint. 4. The under surface, which is uninterrupted and rather convex. And, 5. the upper facet, or small square facet, between the tapering edge and the back, which receives the upper claw of the cock; it is slightly concave. In order to fashion the flint, those scales are selected that have at least one of the above mentioned longitudinal ridges. The workman fixes on one of the two tapering borders, to form the striking edge; after which the two sides of the stone that are to form the lateral edges, as well as the part which is to form the back, are successively placed on the edge of the chisel, in such a manner that the convex surface of the flint which rests on the forefinger of his left hand, is turned towards that tool. He then with the round hammer, gives some slight strokes to the flint, just opposite the edge of the chisel underneath; by which means the flint breaks exactly along the edge of the chisel.

The last operation is to trim, or give the flint a smooth and equal edge. This is done by turning the stone, and placing the edge of its tapering end on the chisel, in which situation it is completed by five or six slight strokes with the wheel hammer, and becomes of the figure represented at *l* and *m*.

The whole operation of making a gun flint is performed in less than one minute. A good workman is able to manufacture a thousand good chips or scales

Fig.





a day, if the flint nodules be of good quality; and in the same manner he can fashion five hundred gun flints in a day, so that in the space of three days he is able to cleave and finish a thousand gun flints without farther assistance.

When the gun flints are completed, they are sorted into two classes, fine and common flints, and according to their application, into flints for pistols, fowling pieces, and muskets. A good flint will give fifty strokes without being unfit for service.

Gems altered by Art.

Lapidaries are accustomed to improve and change the colours of gems by exposing them to heat, and other chemical agents.

In India yellow carnelians are put into an earthen pot, covered with dry goats' dung, and heated for twelve hours, by which they are changed into a fine red. Instead of goats' dung, sand may be used.

Black rock crystal is rendered colourless by heat, if continued for some hours; otherwise it will be only yellow.

Bucquet made a chemical distinction between rock crystal and quartz; the latter, cracking by heat, probably on account of containing water.

The amethyst by a moderate heat becomes colourless; but if the heat is violent, white and shotten like an opal, it is more liable to crack in the fire than rock crystal.

Beryl is changed by a moderate heat to a light blue; if the heat is greater it becomes like mother of pearl.

The emerald acquires the same pearly lustre by heat.

The colour of the chrysoberyl is not altered by heat.

Blue fluor spar is changed to red, and if the heat is strong, is often rendered colourless.

Agates absorb oil, either by being immersed or boiled in it for a sufficient time, or even during the process of cutting them; and on boiling them in oil of vitriol, the parts which have absorbed the oil are rendered black, while the other parts retain their natural colour, or even become whiter than before.

Agates and carnelians having carbonate of soda applied to them, and then exposed to the heat of a furnace under a muffle, an opaque white enamel is thus made to cover the stone, which cannot easily be distinguished from a natural white flake. By this means are produced the carnelian beads brought from India, which are ornamented with a net work of a white colour, penetrating to a small depth, and equally hard as the stone itself.

Glass.

Glass is one of the earliest and most valuable productions of chemical art. The mummies in the Catacombs near Memphis, are ornamented with glass beads, as also, those of the Thebaid, so that it was known 1600 years before the commencement of our era; yet it is not mentioned by any of the writers in the

compilation of the ancient Jewish writings called the Old Testament. Among the Greek writers Aristotle is the first person who mentions it, and it is not mentioned by any of the writers collected in the New Testament, except in the epistles of Paul and Peter, and in the work called the Revelation. Glass was little known even in Rome before 536 U. C. (or 213 A. C.) nor used for windows before Nero; Martial mentions it as applied to the green house or hot house. It was introduced into England about 670 by Theodorus, archbishop of Canterbury. By glass we enjoy the sight of surrounding objects without being exposed to the inclemency of the weather; and are enabled to observe the action of heat and mixture in transparent bodies, far better than we could in opaque vessels made of pottery ware.

The manufactory of glass is mostly carried on by large capitalistists, who use glass houses which are usually conical domes from fifty to eighty feet in diameter at bottom, and sixty to one hundred feet high, in order to ensure a good draught. The principal furnace is erected in the centre, over a large vault extending across the whole area, and allowing a passage to workmen with barrows to extract the ashes. The furnace in the British Islands is built with fire-bricks, set with Stourbridge clay; but on the continent it is more commonly made of raw clay rammed together, and then baked into a solid mass by a fire made in it and slowly and gradually increased. Holes are left on the sides to introduce the fuel and pots, and those for the latter purpose are partly bricked up, leaving only a hole for filling or emptying the pots. The crucibles or pots in which the glass, or metal as the workmen call it, is melted, are made of an infusible clay; in these islands that of Stourbridge is chosen, either kneaded by itself, or more generally with a mixture of a small proportion not exceeding a fourth part of the upper part of old pots reduced to powder. The pots are sometimes made in moulds by a screw press, but the most usual method is that of the French portable furnace makers, namely, to knead the clay until it is rendered as tough as is possible, then make it into rolls, and press these together with the hands and a mallet.

The crucibles or pots for bottle and window glass, are generally forty inches deep, as many wide at top, and thirty at bottom; they are not covered, and are from three to four inches thick. The pots for flint glass are of various sizes and shapes, and are covered with a spherical dome. They are from two to three inches thick, and have a semicircular opening on the side towards the top, to which is fitted a stopper.

The changing of the pots in a furnace is the most severe labour in chemistry. Being first thoroughly dried, they are

heated in a furnace built expressly for this purpose, by a fire increased gradually for four or five days, until they are brought to a white heat. When ready, the opening in the glass furnace has the bricks with which it is partly closed removed, and the old pot pulled out with iron hooks. An operator then puts on a hood, jacket, and pantaloons, formed of raw hides, thoroughly soaked in water, so as to sheathe himself entirely, except the parts opposite the eyes, which are defended by very thick plates of glass, and the pot being taken from the annealing arch, is instantly put by him into its place in the furnace by his hands only, without extinguishing or even diminishing the fire; after which the opening is again bricked up, except the hole left for working the glass.

Bottle Glass.

This is the coarsest kind of glass; in some countries it is made from various kinds of stones, as basalt, or lava; it may also be made from common sand or lime, with a little clay and common salt. But in England it is made from coarse sand and the waste earth of kelp from which soap boilers have washed out the alkali.

The bottle glass furnace is represented in Fig. 119, and is generally an oblong square chamber, covered over with a higher or lower arch, according to the fancy of the manufacturer. The grate is in the middle, and on each of the long sides is a bank a foot high and three wide, upon each of which a couple of pots are placed. The fire doors are at the narrow ends, and are closed with sliders, *a*. The openings at which the pots are put in are bricked up, except a square working hole about a foot each way.

A calcining furnace, *b*, is built at each angle, with two holes of a foot square, one to allow the flame to enter the furnace, the other to manage the materials in them.

Two of these calcining furnaces are called the coarse arches, and are used for calcining the soap makers' waste, where it is kept red hot during the 24 or 30 hours that the melting journey, or time of melting the glass, usually lasts.

The ashes, as the waste is called after this operation, are then taken out and mixed with common winter sand, according to the strength of the ashes, the most general proportion being three bushels of ashes to one of sand. The mixture being effected, is put into the other two calcining furnaces called the fine arches, and calcined during the ten or twelve hours that the working journey, or time of blowing the bottles, lasts. When the working journey is over, the pots are re-filled with the red hot materials out of the fine arch, which takes about six hours to melt; more materials are then added, and this second filling requires about four hours more firing before it is melted.

The melting being accomplished, the heat is kept up to fine the glass from twelve to eighteen hours; when the doors of the ash vault are shut, the glass as it cools throws up its impurities, which are skimmed off. The furnace is then filled with coal, so as to retain a working heat for four or five hours, during which the bottles are blown; a farther addition of coal is then

made, to keep it in a working heat till the whole of the glass is blown into bottles; six persons are employed in the blowing of each bottle.

The bottle glass house generally contains, besides the proper glass furnace, six other furnaces, or arches, for annealing the bottles by cooling them gradually; and two furnaces for annealing pots previous to setting them in the furnace.

Best Window Glass.

This is generally made from fine sand, with about twice its measure of the best kelp. That of the Orkney Islands is preferred to the Western Island kelp; but Bowles, a celebrated manufacturer of this glass, used Spanish barilla, as being still purer.

The calcining furnace, in these houses, is entirely separate from the fondering or melting furnace. It is about six feet square, having an arch thrown over it about two feet high. The bottom of the bank on which the materials are placed, about six Cwt. at a time, is about three feet and a half from the ground. To prevent the alkali from being lost, an iron plate is sometimes built in under the bottom of this bank, but others prefer to form air flues, to keep the bottom of the chamber so cool as to fix the alkali, and thus stop its passage.

The materials are calcined in this furnace at first with a gentle heat for three hours, keeping it continually stirred; the heat is then raised, so as to nearly melt it, and this heat is kept up for about two hours; at the end of which time the frit is drawn out of the furnace, upon an iron plate, and before it cools divided into large cakes, which are piled and kept for at least six months before they are melted, or longer if the manufacturer is possessed of sufficient capital.

The pots in the fondering furnace are filled with this frit, and upon it is piled about one-eighth its weight of broken glass. In ten or twelve hours' firing the frit is melted, and a fresh parcel is then added, which melts, and the whole is left to settle, until the glass or metal becomes fine, and fit for blowing. This fondering requires thirty or thirty-six hours' intense heat; the heat is then diminished gradually in two hours to a working heat, during which the glass settles.

Fig. 120, represents the furnace used for melting the best window glass. It is usually of such size as to hold four or six pots, capable of containing sixteen or even twenty Cwt. of glass. Besides this furnace and the calcining arch, the house contains a flashing furnace, and bottoming hole for working the glass, along with several annealing arches, as well for the glass as for the pots, to supply the place of those that become cracked.

Crown glass is usually blown first into a globe, and then the globe is heated by rapidly twirling it opposite to the working hole, which softens the part of the globe opposite the neck,

Fig. 119

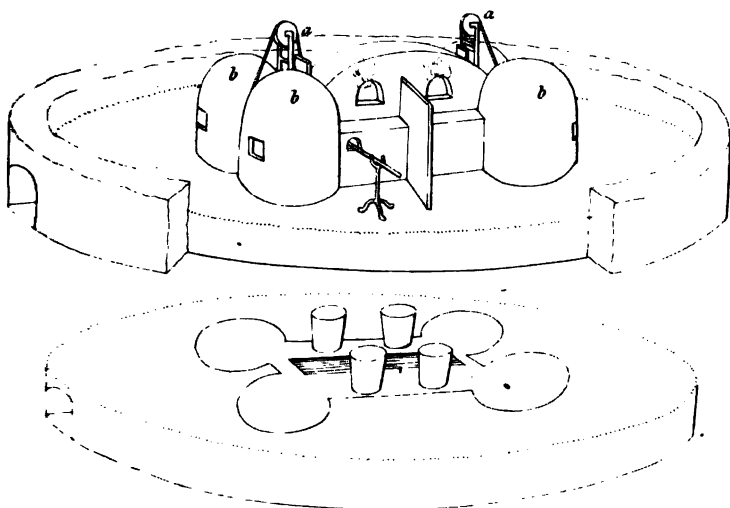
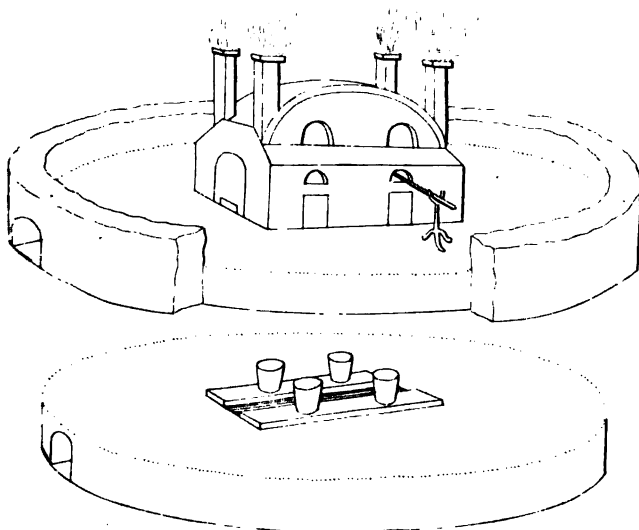
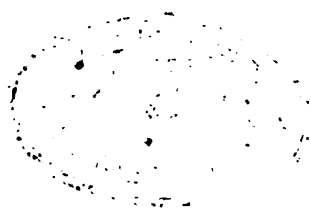
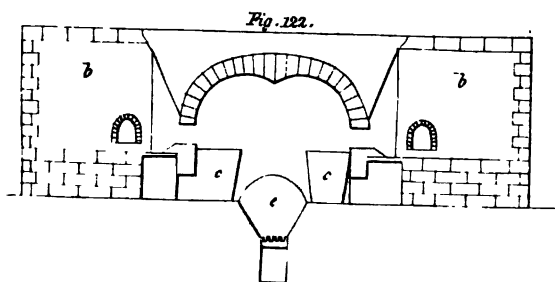
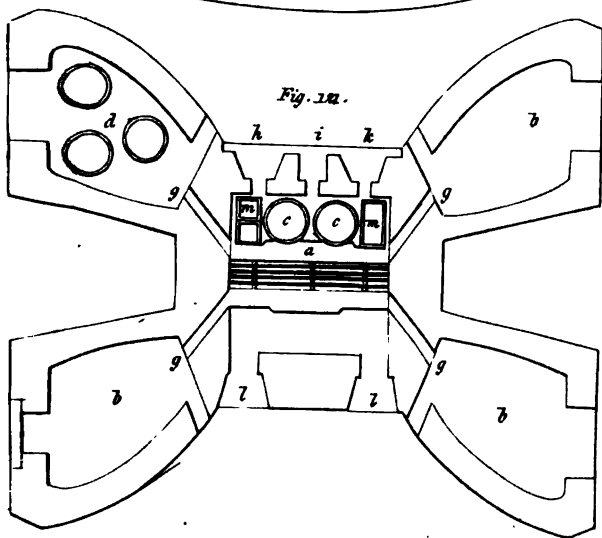
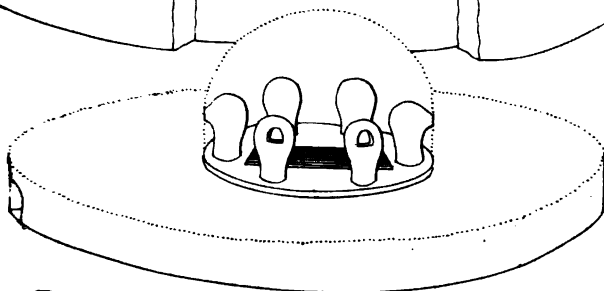
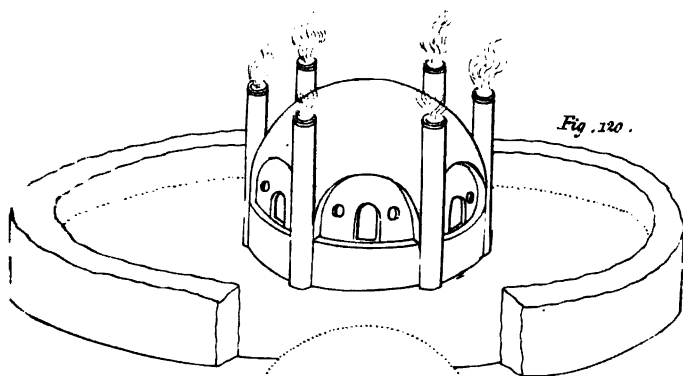
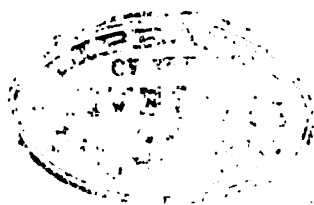


Fig. 120









and thus by the centrifugal force of its particles, the globe is expanded into a slightly convex plate; being suffered to cool a little, the glass is separated by the application of a cold iron from the blowing tube, and taken up on another iron, fixed by melted glass to the centre of the part opposite the neck; it is then softened by heat, and being rapidly twirled, the neck opens, and at a certain period the now conical frustum suddenly changes to a flat circular plate, with a knob in the centre.

The same glass is sometimes made into window plate, German plate, or table glass. In this case the glass is blown into a large cylinder, which being cut, while soft, longitudinally by a pair of shears over a copper table, it sinks down into a flat table, and is carried to the annealing arch.

Flint Glass.

This is so called, because it was formerly made of calcined flints; but at present a fine quartzose sand, found at Lynn, is employed as the basis; this sand is well washed, calcined, and sifted, in a sieve of fifty meshes to the inch, running measure. The flux is composed partly of red lead, or which is generally preferred, of litharge, and of purified pearl-ash; the proportions being 100 of sand, 60 of red lead or litharge, and 30 of purified pearl-ash. Soda makes a harder glass than pearl-ash. but it communicates a greenish blue tinge, and therefore will not do for the generality of articles, for which flint glass is used, as they require the utmost clearness and freedom from colour. Saltpetre is added in small quantities, to secure the oxidation of the lead; white arsenic is also added, with the same intention, but care must be taken that too large a quantity is not added, as this would produce a white cloudiness in the glass. Another oxidizing ingredient scarcely ever omitted, is black manganese, to change the greenish yellow, or olive tinge, given by the iron contained in the sand into a purple tinge, but it greatly injures the transparency. Hence a necessity for employing the purest sand, oxide of lead and pearl-ash, that can be procured, for manufacturing flint glass.

Fig. 121, represents a flint glass furnace, which is constructed so as to yield a greater heat than the preceding furnaces, in order that the glass may run thin, and thus the impurities, or sandiver, rise the easier through the liquid mass.

The pots used in fusing flint glass, are in English glass houses always covered, on account of coal being used for fuel. The materials are taken from the mixing house to the glass house, and about a dozen shovelfulls are put at once into each pot; in two or three hours this is melted, and more is added, till the pot is full. The mouth of the pot is then closed up, by putting soft clay round the stopper, except a small opening, through which the sandiver escapes, in consequence of the melted glass being hotter at the side next the

fire than next the mouth. As soon as the glass is fine, and free from all air bubbles, the workmen begin to blow it into wares.

The manufacture of flint glass for optical purposes, particularly for telescopes, requires extraordinary care, as the veins which usually exist in flint glass, on account of the great difference in specific gravity between its ingredients, are very prejudicial to the accuracy of the image. Dollond, the optician, was once lucky enough to find a large mass of flint glass free from veins, but no method is known of securing this valuable quality in a batch of glass.

M. Cazalet, of Bordeaux, has, indeed, proposed the following materials, as capable of forming a glass free from veins, and other imperfections: one hundred pounds of red lead, sixty of white sand, fifty of refined saltpetre, and one of fine white chalk. And an ingenious Swiss artist is said to have discovered a successful method of constantly forming this desirable article.

Plate Glass.

This, though not the finest glass, is remarkable for the mode of its being rendered fit for use, which is not by blowing, as in the other kinds, but by casting in sheets like lead; hence it must not be liable to fix too soon, as this would hinder it from being spread on the moulding table.

The sand used for plate glass is usually fluxed with purified barilla, with some addition of pearl-ash; borax, and a small proportion of quicklime, are also used for facilitating the melting, and black manganese to prevent the yellow or red tinge arising from the accidental presence of oxide of iron, and to give the glass a dark tinge, which increases its reflective power, as it is mostly used for looking-glasses. Each manufacturer has his own proportions of materials. Parkes mentioned one who used 430 parts of very white sand, 265 of dry carbonate of soda, procured by acting upon common salt by pearl-ash, forty of quicklime, and fifteen of refined saltpetre. The materials are mixed together, and calcined in the chamber of a reverberatory furnace for five or six hours.

Fig. 122, represents a plan, and 123, a section of the fonding furnace of a plate glass house. The proper furnace, *a*, which contains two pots on each side, is surrounded by four chambers, *b*, *d*, which are heated by the flame passing through the bridges, *g*. Three of these chambers, *b*, are used for burning the pots and cisterns; the fourth chamber, *d*, fritting the materials before they are put into the melting pots.

The fire is made in the grate, at *e*, fig. 123, which is included between the two sloping sides of the banks on which the pots, *c*, and cisterns, *m*, are placed. The fuel is supplied through the arches, *e*, fig. 123, which are of sufficient

size to introduce new pots, but are then bricked up, except a small hole at bottom. On each side of the furnace are three working holes, *h*, *i*, to admit the iron ladles by which the glass is put into the pots, or when melted, laded into the cisterns. Openings, *l*, are made on a lower level, by which the cisterns may be put in, or drawn out of the furnace; and in this level is placed an iron floor, as shown by the dotted lines, to receive the cisterns.

To bake the pots or cisterns gradually, the flues, *g*, leading to the chambers, *b*, are provided with dampers; these being shut, the pots or cisterns are placed in the chamber; after which, the dampers are gradually opened to admit the heat gradually, and avoid the danger of cracking the pots or cisterns.

The frit taken from the reverberatory furnace is mixed with a quarter its weight of broken plate glass, previously reduced to powder by heating it in the chamber, and throwing it while hot into cold water. After which, it is mixed with the frit, and other materials, and the composition is again calcined for some hours in the same chamber, until they begin to melt.

This thick paste is laded out into the pots, where, by thirty-six or forty-eight hours' firing, they are converted into glass. Some of this glass is then taken out, and if thick, or imperfectly melted, some borax is usually added, and if too coloured, black manganese, white arsenic, or a mixture of these oxides is wrapped in brown paper, and thrust down to the bottom of the pot.

When the glass is fine, it is laded out of the pots into the cisterns, where it remains five or six hours; and then the cistern being withdrawn, its contents are poured out upon a thick copper table, brought for that purpose to the opening, *l*, by which the cistern is withdrawn. To regulate the breadth and thickness of the plate, two iron ledges, of the required thickness, are laid upon the table, and a copper roller, weighing about five Cwt., pushes the liquid glass before it. The plate is then shoved, as quickly as possible, into an annealing furnace, where it remains for fourteen days, cooling gradually.

The plates thus made, are then ground level by sand, and polished by emery of different finenesses, by Tripoli, and putty powder.

The above quantity of materials produce about 700 parts of plate glass.

Glauber's salt may be employed in glass making without any addition of potash or soda, and it makes beautiful and white glass. It does not indeed vitrify quartz perfectly, even in the strongest fire. The fusion is more complete if lime is added, but even this requires a deal of time and fuel. By decomposing the sulphuric acid the vitrification is quite perfect. For

this purpose the best medium is charcoal, or for flint glass, metallic lead.

This decomposition may be effected during the fusion, or previous to it, but there must be observed:—The property charcoal has of colouring glass, even when in very small quantity, in which it is not exceeded by any of the metallic oxides. A preference is to be given to lime reduced to powder, dissolved in water and heated again, before lime slaked in the air.

The great effervescence of the glass, so that it must be added in smaller portions than if potash was employed. Sulphuret of soda may be more useful in glass making than the sulphate. The pots must be of good clay, as the sulphate of soda acts violently upon them; the best proportion for drinking glasses is 100 parts of sand, 50 of dry Glauber's salt, from 17 to 20 of lime, and 4 of charcoal. Sulphate of soda dissolves more silica than potash. Sandiver is decomposed by adding charcoal. Glass made with felspar containing potash, generally abounds with blebs, yet it is possible to make good glass with it.

If a small quantity, even a pint of water were to be thrown into a crucible of glass in a melted or rather a melting state, while the scum or sandiver is upon its surface, the water would be converted instantly into steam, so that an explosion would take place; and if the quantity of water were more considerable, the furnace would probably be blown down. Indeed, the taking off the sandiver in iron ladles, and plunging them in water, has been used to salute visitors of importance, with explosions like a salute of ordnance. But when the sandiver has been scummed off, and the glass in quiet fusion, if water is thrown on it, the globules dance upon the surface of the melted glass for a considerable time, like so many globules of quicksilver upon a drum head, while the drummer is beating it; and on this account, when melted glass is flung into water to calcine it, care must be taken to skim it well, before it is ladled out.

In the manufacture of black bottles it frequently happens that while the workmen are employed in moulding and blowing the bottles, that the glass, or metal as it is called, becomes too cold to work, so that they find it necessary to desire the firemen to throw in coal and increase the heat.

This, however carefully it may be done, will sometimes produce so much dust that the surface of the glass becomes covered with coal dust. When this accident occurs, it occasions such a motion within the melting pot, that the glass appears as if it were actually boiling; and if the metal was used in this state every bottle would be speckled throughout and full of air bubbles.

Whenever this circumstance takes place, the workmen throw a little water into each of the melting pots. This water has the effect not only of stilling the boiling of the glass immediately, but it also renders the melted metal as smooth and pure as before.

ARTIFICIAL GEMS.

A number of authors have given receipts for making those coloured glasses which are employed in cheap jewellery as substitutes for the more valuable gems.

Amongst these authors M. Fontanieu seems to be the person who has given the simplest, and therefore probably the best formulæ for composing of these coloured glasses.

For M. Fontanieu's colourless base, crystal or pebbles being pounded are put into a crucible and heated red hot; the contents are emptied into cold water. The water is then decanted, and the mass being dried and pounded, is sifted through a sieve of the finest silk, after which the powder is digested in muriatic acid, and being frequently washed, is again dried and sifted for use. From the earth thus obtained, M. Fontanieu formed six different bases, of which the fifth seems to be that which, in respect of quality, is preferred by himself.

The first base is formed by twenty ounces of litharge, twelve ounces of prepared rock crystal or flint, four ounces of arsenic, which being well pulverized and mixed, are melted in a Hessian crucible, and poured into cold water. The mass is melted again the second and a third time, always in a new crucible, and after each melting poured into cold water as at first, taking care to separate any lead that may be revived.

The second is obtained from a mixture of twenty ounces of white lead, eight ounces of prepared flint, four ounces of purified pearl-ash, and two ounces of calcined borax, all melted in a Hessian crucible and poured into cold water. The melting must be repeated, and the mass washed a second and third time with the same precautions as before.

A compound of sixteen ounces of red lead, eight ounces of crystal, four ounces of saltpetre, and four ounces of purified pearl-ash, constitutes the third base, being treated as in the preceding examples.

The fourth is formed by eight ounces of rock crystal, twenty-four ounces of calcined borax, eight ounces of purified pearl-ash, mixed and melted together, and poured into warm water. The mass being dried, an equal quantity of red lead is to be added, and the whole repeatedly melted and washed as before.

The fifth, or Mayence base, is thus made: Eight ounces of rock crystal, or flint pulverized, is baked along with twenty-

four ounces of purified pearl-ash, and the mixture left to cool. The frit is afterwards poured into hot water to moisten it, and the nitric acid added until it no longer effervesces. The water being decanted, the frit must be washed in warm water until it ceases to have any taste, and the frit being then dried and mixed with twelve ounces of fine white lead, the mixture is to be well levigated with a little distilled water. An ounce of calcined borax is now to be added to twelve ounces of this powder when dried, and the whole well mixed, then melted and poured into cold water, in the same manner. After repeating these fusions five drams of nitre are to be added and the whole melted. A mass of crystal having a beautiful lustre will be found in the crucible.

Lastly, a very fine white crystal glass may be obtained from eight ounces of white lead, two ounces of borax finely powdered, half a grain of manganese, and three ounces of rock crystal, treated as the rest.

The colour of artificial gems is obtained from metallic oxides. The diamond being colourless is imitated by the Mayence base, or strass as it is called, and M. Fontanieu has given numerous receipts for making all other fictitious gems, of which the following are examples.

Oriental topaz is imitated by adding 360 grains of antimony to colour 13,834 of the first or third base. Amethyst by taking 13,834 grains of the Mayence base, to which are to be added 288 of manganese, prepared by being exposed to a red heat and quenched in distilled vinegar, then dried, powdered, and passed through a silk sieve, and also four grains of the purple precipitate of Cassius.

The beryl is imitated by 96 grains of antimony and four grains of oxide of cobalt, added to 13,834 grains of the third base.

The yellow diamond; by melting 24 grains of muriate of silver, or ten grains of glass of antimony with 576 grains of the fourth base. The sapphire by 13,824 grains of the fifth base and 190 grains of oxide of cobalt. The emerald by 8640 grains of any base, with 72 of mountain blue, and 6 of glass of antimony. The common opal by 576 grains of the third base, 10 of muriate of silver, 2 of calcined loadstone and 26 of lime.

M. Donault Wieland has given some other formulæ; and observes that Hessian crucibles are far better than those of porcelain for melting the compositions, and that the glass should be kept for 24 hours in a uniform heat since the beauty depends greatly upon this long continued and tranquil fusion.

Colourless glass or paste:

	No. 1.	No. 2.	No. 3.	No. 4.
Rock crystal calcined,	4056	—	3456	3600
Sand,	—	3600	—	—
Red lead,	6300	—	5328	—
White lead,	—	8508	—	8508
Purified pearl-ash,	2154	1260	1944	1260
Borax,	276	360	216	360
White arsenic,	12	12	6	—

For artificial topaz he takes 1008 grains of colourless paste, 49 of glass of antimony, and 1 of Cassius' purple precipitate; or 3456 grains of paste, and 36 of red oxide of iron made by fire. For ruby, 2880 grains of paste, and 72 of black manganese. For emerald, 4608 grains of paste, 42 of green oxide of copper, and 2 of oxide of chlorine. For sapphire, 4608 grains of paste, 68 of oxide of cobalt, and 1 of Cassius' precipitate. For beryl, 3456 of paste, 24 of glass of antimony, and one and a half of oxide of cobalt. For the Syrian garnet or carbuncle, 512 of paste, 256 of glass of antimony, 2 each of Cassius' precipitate and of black manganese.

Stained Glass.

This art has been repeatedly described as being no longer known; but this is not the case, except in respect to some particular colours which are found in church windows.

M. Brogniart, director of the porcelain manufactory at Sevres, has made many experiments on painting on glass, or staining it, as the art is more usually called.

The glass used for staining should not have any oxide of lead in its composition, and the colours are the same as those used in enamelling.

A very beautiful violet, but liable to turn blue, is made from a flux composed of borax and flint glass, coloured with one-sixth part of the purple precipitate of Cassius.

A fine red is made from red oxide of iron, prepared by nitric acid and fire, mixed with a flux of borax, and a small proportion of red lead.

A yellow, equal in beauty to that produced by the ancients, may be made from muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron mixed together without any flux. A powder remains on the surface after the glass has been baked, but this is easily cleaned off.

Blue is produced by oxide of cobalt, with a flux composed of fine sand, purified pearl-ash, and red lead.

Black is produced by mixing the composition for blue, with the oxides of manganese and iron.

To stain glass green, it must be painted blue on one side, and yellow on the other.

The colours ground with water being laid upon the glass, must be exposed to heat under a muffle, so as to be heated equally until the colour is melted upon the surface. To prevent the panes of glass from bending, they are placed upon a bed of bone ashes, or of quicklime, or, as M. Brogniart ordered his painters to proceed, upon flat plates of biscuit, that is, unglazed porcelain. A bed of gypsum has been recommended, but the sulphuric acid exhaling from it is apt to render the glass opaque, white, and cracked.

Glass Beads.

Drs. Hoppe and Hornschuch in the Journal of their tour to the coast of the Adriatic sea, give the following account of the far famed manufactory of glass beads, carried on at Murano, a place adjoining Venice.

The furnace and the white glass are similar to what is seen in the common glass houses; but they mix with this white glass peculiar colouring substances of which they make a great secret. The coloured glass being reduced to a melted state, a certain quantity is taken up by the blow pipe used by the workmen, and is blown hollow; a second workman lays hold of the other end of the glass ball, and both the workmen run with great expedition two opposite ways, and thus draw out the glass into pipes, the thickness of which differ in proportion to the distance. A long walk of 150 feet, like a rope walk, is attached for this purpose to the glass house.

As soon as the pipes are cooled they are divided into pieces, all of the same length, sorted, packed in chests, and sent to the bead manufactory in Venice itself. Striped pipes are made by taking two lumps of glass from pots of different coloured glass, twisting them together, and then drawing out the whole to the proper length. They also manufacture pipes three feet long and of the thickness of a finger; these have a ball blown at one end, and are used to tie up plants in flower pots.

When the pipes arrive at the bead manufactory in Venice, a person picks out pipes of the same thickness, which he cuts into small pieces of the size he thinks necessary. For this purpose a sharp iron in the shape of a broad chisel is fixed in a wooden block; the workman places the pipes of glass on the edge of this tool, and with a chisel-like tool in his right hand, he cuts, or rather chips the pipes into the sizes that are proper for the various sized beads.

These fragments of the pipes are then put into a mixture of sand and wood ashes and stirred until the hollow of all the pipes

are filled, in order to prevent their sides from running together by the heat of the fire. They are then placed in a vessel with a long handle, more sand and wood ashes are added, the whole placed over a charcoal fire, and stirred continually with a spatula resembling a hatchet with a round end; by this simple means they acquire a globular figure. The sand and wood ashes are then separated by sifting, and the beads themselves sorted by other sieves into different sizes. Each size are then strung upon threads, made up into bundles, and packed ready for exportation.

The extent to which this manufactory is carried is astonishing; many hundred weight stand ready filled in casks, to be sent to all parts of the world, but particularly to Spain and the coast of Africa.

Moulded Gems.

The extreme beauty of many engraved gems and their high price render the taking of copies from them in coloured glass a very desirable art. M. Homberg has given the following minute directions for this purpose.

A quantity of soft, smooth, red Tripoli is pounded in an iron mortar, sifted through a fine silk sieve, and set aside for use. Another species, called yellow or Venetian Tripoli, which has a natural kind of unctuousity, is then scraped with a knife, and bruised in a glass mortar with a glass pestle, until reduced to a very fine powder: the finer it is the more favourable for the impression. The red Tripoli is now to be mixed to the consistence of paste with water, and when moulded between the fingers it is put into a small flat crucible, scarcely exceeding half an inch in depth, and little more in breadth at the surface than the size of the gem whose impression is to be taken. The crucible is then to be filled with the paste slightly pressed down into it, and the dry yellow Tripoli strewed over its surface. Upon this bed the stone which is to give the impression must be laid, and pressed down so much on the paste as to give it a strong, clean, and perfect impression; and the Tripoli is to be collected and applied nicely to the edges with the finger or an ivory knife. After the stone has lain a few seconds to allow the humidity of the red Tripoli paste to moisten the dry powder of the yellow Tripoli scattered over it, the operator must raise it carefully by a needle fixed in a wooden handle, and the crucible being inverted, it will fall out, while the impression remains on the Tripoli still adhering to the crucible. The stone must now be examined to ascertain whether any of the paste has come off along with it; as in that case there would be a corresponding defect in the impression, and the moulding must be repeated. Having allowed the crucible and paste to dry, the artist selects a piece of coloured

glass of the suitable size to be laid over the mould, but in such a manner as not to touch the impression, which would thus be obliterated or injured, and the crucible being gradually brought nearer the furnace is to be heated until it can no longer be touched by the hands, when it must be placed in the furnace under a muffle, surrounded with charcoal. When the gem begins to appear bright, it is the sign of being ready to receive the impression. The crucible must now be taken from the fire and the hot gem pressed down with an iron implement, to make it receive the impression from the mould below it; after which the crucible is to be set by the sides of the furnace to cool gradually without breaking. When cold the gem may be removed, and its edges nipped or grated round the pincers to prevent it from cracking, which sometimes happens.

Red Tripoli is used for the paste only from economy, as it is the yellow species alone which is adapted for the purpose. Casts of plaster of Paris made into small cakes half an inch thick, may in some cases be substituted for Tripoli moulds, and being put into a furnace without a crucible and heated, the coloured glass may be pressed down upon it to take the impression.

Another species of these moulded gems is that which was adopted by Mr. Tassie. In these copies the original transparent or semi-transparent gem is not attempted to be imitated, but the copy is taken in a beautiful white enamel, sufficiently hard to strike fire with steel.

Reaumur's Porcelain.

It had been frequently observed that during the annealing of green glass, some parts of it became white and opaque; M. Reaumur made experiments on this apparent devitrification of glass, and found that it was owing to the alkali flying off by the too long continuance of the heat, or its excessive power, and that the opaque changed glass had acquired the quality of bearing sudden transitions of heat and cold as well as the best porcelain.

For the purpose of making vessels of this kind, common bottle glass is chosen, and blown into the proper form. The vessel is then to be filled to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessels must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it remains during the whole time that the pottery is baking, after which the glass vessel will be found changed into a milk-white porcelain.

The glass, on fracture, appears fibrous, as if it were composed

merely of silken threads, laid by the side of each other; it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel, though not so briskly as real porcelain. Lewis observed that the above-mentioned materials have not exclusively the effect upon glass, but that powdered charcoal, soot, tobacco-pipe clay, or bone ashes, produce the same change. It is remarkable that the surrounding sand becomes in some measure agglutinated by this process, which if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it incoherent, and reducible with great ease to a kind of sand.

Ultramarine Blue.

This precious colour is obtained from the stone called lapis lazuli, by heating it, reducing it to powder, by throwing it while hot into water, then washing away the lighter particles by water, and grinding it very fine. The ground stone is then incorporated into a melted mass formed of equal parts of rosin, wax, and linseed oil. The mass is then kneaded with the hands in warm water, the first portion of which is usually rendered dirty; but as soon as a blue colour appears, the water is changed, and then the ultramarine blue is collected, being washed out of the kneaded mass.

As the value of the ultramarine blue is very great, the purchaser is liable to have cheaper substitutes imposed upon him: the genuine blue suffers no change of colour by being heated; nor does it effervesce with oil of vitriol, but in this, or any other strong acid, it loses its colour, and leaves a dirty white sediment, the solution is colourless, and yields a very slight white precipitate with ammonia water: if boiled in carbonate of potasse water, the intensity and brilliancy of its colour is increased.

Ultramarine blue is used to paint the sky as it appears in warm countries; but as this colour does not change by age, like the others used in the same picture, the harmony of the colouring is gradually lost, and the sky becomes too brilliant in comparison with the remainder of the picture.

Smalt, or Powder Blue.

This is a blue glass colour, made by melting three parts of fine white sand, or calcined flints, with two of purified pearl-ash, and one of cobalt ore previously calcined, and lading it out of the pots into a vessel of cold water; after which the dark blue glass or zaffre is ground, washed over and distributed into different shades of colours, which shades are occasioned by the different qualities of the ore, and the coarser and finer grinding of the powder. It is usual to distinguish these blue glass colours

by certain combinations of letters, C, signifying colour; E, eschel, that is to say, ash; F, fine; FF, finer; FFF, finest; H, high; M; middling; and O, ordinary.

Smalt is used in painting as a substitute for ultramarine blue; and to give linen a bluish tinge.

Naples Yellow.

There are two different processes for making this glass colour that have been published.

That of the Abbate Passeri is by calcining one pound of common antimony, and one and a half of lead, with an ounce each of alum and of common salt.

M. Fougereux calcines twelve ounces of white lead with two of peroxide of antimony, one of sal ammoniac, and half an ounce of calcined alum, for three hours, in a covered crucible, till it becomes barely red hot.

Enamel Colours.

Enamel colours are of two kinds, transparent and opaque; the latter quality being caused by adding oxide of tin to the transparent basis of the other enamels, which differs only from coloured glass, by its greater fusibility and softness.

The best opaque white enamel was brought from Venice, in two-pound cakes, marked Bertolini; but this manufacturer being now dead, the article is no longer to be procured. An enamel superior in whiteness, but inferior in its power of retaining a transparent glaze laid over it, has been prepared in London. The cause of this difference is supposed to arise from the Venetian maker having used a pure oxide of Malacca tin; while the others use the common putty powder, thrown out by heat from an alloy of two parts of English tin with one of lead. Upon such slight differences, unnoticed, and indeed laughed at by the philosophical chemists, do the perfection of a manufactured article depend.

Mr. Wynn has lately published the following processes for obtaining enamel colours.

<i>Fluxes.</i>	No. 1.	2.	3.	4.	5.
Flint glass	12	10	3	16	6
Red lead	16	—	1	19	8
Calcined borax	3	—	—	—	—
Flint powder	4	—	—	—	—
White arsenic	—	1	—	—	—
Refined saltpetre	—	1	—	—	—
Borax, not calcined	—	—	—	11	—
Flux, No. 2.	—	—	—	—	4

The materials for these fluxes are to be well melted, and then poured out upon a flag-stone wetted with a sponge full of water,

or into a large pail of clean water; then dried, and finely powdered in a Wedgewood-ware mortar.

For yellow enamel, mix eight parts of red lead with one each of the peroxides of antimony and tin; heat the mixed powder upon a Dutch tile, under a muffle, till it becomes red hot, then let it cool: by varying the proportion of antimony, different shades of colour may be obtained. To two parts of this calcined powder add three of flux, No. 4, and grind them together in water for use.

Orange-coloured enamel is producible from twelve parts of red lead, four of peroxide of antimony, three of flint powder, and one of calcined green vitriol; mix and calcine them together, without melting: to two parts of the calcined powder is then added five of any flux, and the whole melted.

Dark red enamel is produced from seven parts of green vitriol calcined to a dark red colour, six of the flux, No. 4, and one of colcothar; the two latter being previously melted together, and then the whole ground in water.

Light red enamel is made from six parts of the flux, No. 1, three of white lead, and two of green vitriol calcined to redness.

Brown enamel is produced from thirty-four parts of red lead, sixteen of flint powder, and nine of black manganese.

In respect to other colours, oxide of copper produces a green colour, oxide of cobalt, a blue; oxide of iron a very fine black: the oxide of silver also produces a yellow enamel; and oxide of gold a very beautiful red, which stands the fire very well, which is not the case with the red from iron.

Enamel painting is done upon plates of gold, or of copper, whose spring is got rid of by gently hammering the springing parts upon a marble slab with a wooden hammer; annealing them, washing the surface clean with nitric acid. Upon these plates is laid, first on the back with a soft kind of enamel, and then on the front, or face, with hard enamel, ground with water, spread equally on the plate, dried with a fine napkin, and then melted under a muffle. As the flux rises to the surface, by the oxide of tin settling down, the surface is rather more transparent than the bottom, and is used, or ground off by a grit-stone, leaving a uniform rough surface, much whiter than before.

The plate being covered with enamel, and fired, the surface is painted and again fired.

ALUMINE.

Alumine was originally called *earth of alum*, from the method used to obtain it, by adding alum water to ammonia water,

taking care not to add so much alum water as to saturate the ammonia; a white spongy sediment falls down, which is to be well washed, and then dried.

Like the other earths, alumine is supposed to be the oxide of an unknown metal, called, by anticipation, *aluminum*. Berzelius makes alumine to be Al_2O_3 and its weight 642,330; but Dr. Thomson, only Al equal to 2,250.

Alumine is of no use; but it gives their characteristic qualities to clays; although it is not the most weighty ingredient in them; it is also the basis of bricks, tiles, and all pottery wares.

Pottery Ware.

A number of clays are used in the manufacture of this article, which now forms one of the staple manufactures of the kingdom, and gives employment to a vast number of people.

Cornish stone is a species of granite in a state of decomposition, and contains much felspar.

Cornish porcelain clay is this stone more fully decomposed, so that being broken to pieces, and a stream of water directed over them, the clay is washed out, and carried into pits, where it is left to settle and dry; the dried clay is cut into cubic lumps, which are extremely white.

Devonshire black clay is a bituminous porcelain clay, which becomes white on being burned.

Devonshire cracking clay becomes of a beautiful white when burned, but unless the proper proportion of ground flints are mixed with it, the ware will crack in baking.

Dorsetshire brown clay burns very white without cracking, but the baked ware does not readily imbibe the glaze. It is also very difficult to make into a slip that will pass through the silk lawn sieves, unless it has been long exposed to the weather; and the colour of that procured of late years is inferior to that dug formerly, hence many manufacturers will not use it.

Dorsetshire blue clay is very expensive, but forms a very white and solid ware; it requires much ground flint, and a high degree of heat for baking it.

Cheam clay is used for the body of gallipots, and affords a buff-coloured ware.

Bradwall wood clay is a red brick clay.

Hallfield colliery clay is a marle, which burns to a light red ware, of four different shades, according to the degree of heat in which it is burned.

Besides these, and some other clays, the English potters use bone-ash, which gives whiteness to the ware, but renders it liable to crack by sudden changes of temperature.

Ground flints, cawke-stone, called also sulphate of barytes, and ochre obtained by letting the water which flows out of coal pits settle in ponds, are also used in great quantities.

The clays and other materials are made up separately into pulp, or slip, about the consistence of cream, and passed through fine silk lawn sieves; the average weight of the ale pint, or 35 cubic inches .25 of the pulp of flint is 32 ounces, that of clay 24.

The pulps are then mixed together in certain proportions according to the kind of ware that is to be made, and the mixture reduced with water until a pint weighs a determinate number of ounces. Each manufacturer has his own proportions, which he keeps as secret as possible. The superfluous moisture is evaporated by pumping the pulp to the top of the slip kiln, which is a trough formed of fire bricks, from 30 to 60 feet long, 4 to 6 broad, and about one deep, with flues underneath; during this evaporation the mixture is continually turned over, to dry the whole as uniformly as possible; with the same view the floor of the trough next the fire is made thicker than in the middle, and the middle thicker than the end next the chimney.

The clay is then cut out of the trough and thrown on a heap upon flag-stone, where it is kept as long as the convenience and capital of the manufacturer will allow.

Before the mixed clay can be used in the manufacturing of wares, all the air bubbles must be got rid of by beating it with mallets, cutting it down in pieces, and violently slapping them together by a strong man, by passing through a mill, where the clay is first cut by knives passing through it, and then instantly squeezed together by other knives below. These operations are repeated until the clay on being cut through by a brass wire, presents a perfectly smooth and uniform surface.

The clay is now formed into the proper shape. The first rough shaping is given on a horizontally revolving slab, called the potter's wheel. The clay being dashed upon the centre, is formed by the wetted hand into a pillar, then flattened into a cake, and this repeated until the thrower is satisfied that no air bubbles remain in the mass. He then forms the vessel with his fingers, and moulds it into its required shape, when the vessel is laid by until the clay has acquired a peculiar state, called the green state, in which the remaining operations of fine pottery are best performed.

Common turning is performed on a lathe similar to that of the wood turner: in which the edges of the ware are dressed by means of tools. Engine lathe turning is employed to give some circular species of hard ware a milled edge, as in tea pots. After this, handles or other appendages which have been previously formed by pressing the clay through an opening of the proper form at the bottom of a syringe, are fastened on by means

of slip. The vessel is then trimmed with a knife, and the whole of the joints cleaned off with a moist sponge.

Other articles of pottery are modelled in clay and plaster of Paris moulds made from the model. The clay is first beat with a lump of clay into the required thickness, and then pressed by the hand into the mould. The mould absorbs the moisture of the clay very quickly, and the ware separates easily from the mould, so that the potter may use the same mould five or six times in the course of the day.

Some kinds of ware whose figures are irregular, and whose strength is not important, are formed by casting in plaster of Paris moulds, which are either made of one piece or of several strapped together.

The mixed clay is mixed with water so as to be of the thickness of cream, and poured into the mould, which immediately absorbs the water from the pulp next it, and thus a coating of clay is attached to the mould; the pulp is then poured out, and the clay left for a short time to dry; when fresh pulp of a thicker consistence is poured in, and when a coating is again formed, the pulp is poured off, and the charged mould placed for a short time near the stove until the vessel will part easily from it.

To preserve the ware from the immediate action of the fire, it is enclosed in cases made of marle, old seggars, as the cases are called, ground, and sand; the bottom of each seggar is covered with a layer of fine white sand to prevent the ware from adhering to it.

The pottery ware of Europe is burned twice; first in the biscuit oven, to give consistence to the ware, and enable it to bear the glaze; secondly, in the gloss oven, to melt the glaze; besides these two firings the finer articles undergo another, after being painted upon the glaze or gilt, or black printed; which firing is performed in the enamel kiln.

Fig. 124, represents a section, and 125, a plan of the biscuit and gloss ovens, which differ only in size, the first being the largest, and having four fire rooms round its central chamber. The plan is taken at the height ** in fig. 124, and the section is in the line ** in fig. 125, except that the front view of the opening, *f*, by which the fire is introduced, and the opening, *o*, for admitting air to the fire, are not included in the section, but represented as they appear externally.

The potter's kiln is a cylindrical cavity covered by a flattish dome; this is surrounded by a conical building, serving as a chimney, reaching something higher than the buildings adjacent. The great space between the cylindric part, which is the proper kiln, and the surrounding circular wall, used to be considerably greater than at present, and even now is much too great, as it does not sufficiently obviate an evil which is equally conspicuous in glass houses and in potter's kilns, for the great quantity of cold air which is constantly ascending the cone tends much to check the draught, and by that means renders the fuel less efficacious. Indeed, the cylindric portion or kiln should so nearly

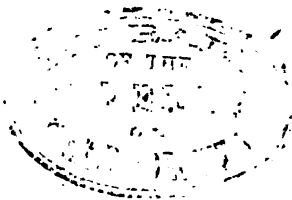


Fig. 124

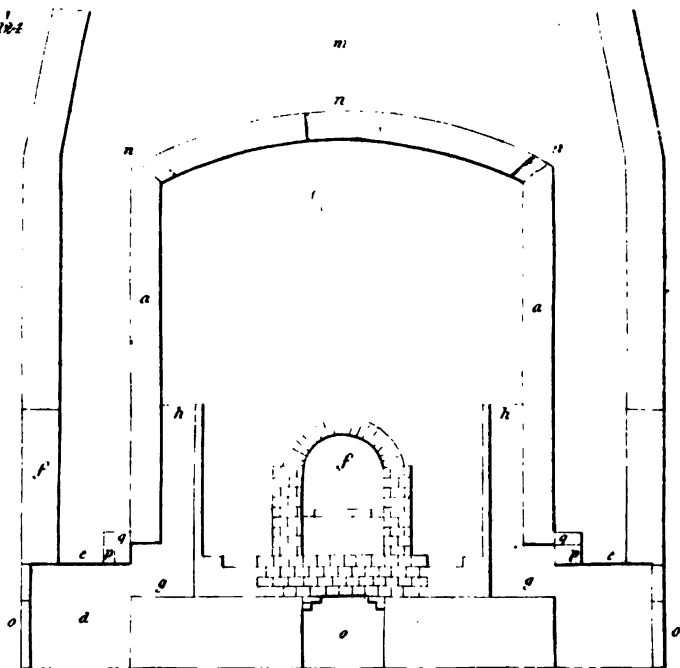
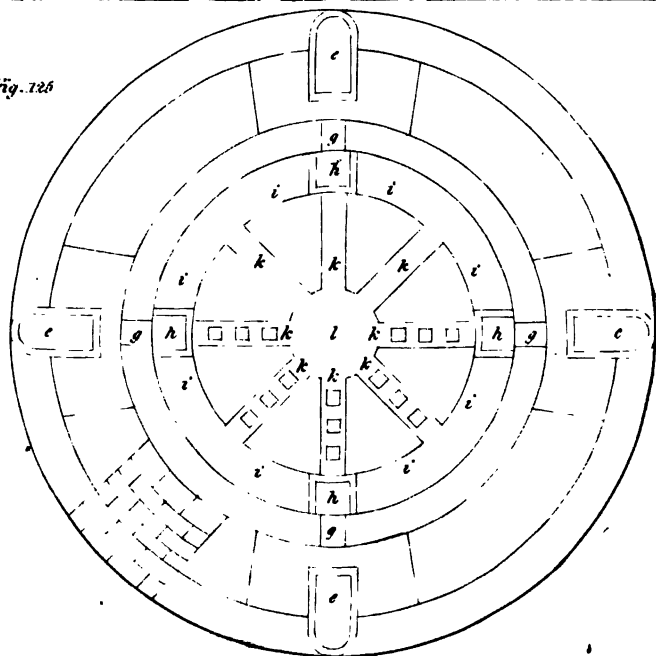


Fig. 126



touch the surrounding wall as would be just sufficient to carry off the waste smoke.

A, is the cylindrical wall of the kiln forming the space, *b*, which is the chamber in which the seggars are piled; in it is a doorway through which the seggars are conveyed, the space being built up with brick when the kiln is filled; *d*, in the section are the spaces occupied by the fire which is introduced at the openings, *e*, which open into the arched recesses, *f*, formed in the surrounding wall. The holes, *e*, are surrounded by frames made of earthenware or cast iron, in the shape of a horse shoe.

The flame of the fire enters the horizontal flue, *g*, from whence it is free either to ascend through the chimney, *h*, or branch into the circular flue, *i*, by which it has access by the intermediate flues, *k*, to the central opening, *l*, from whence it rises perpendicularly to the top of the kiln, where it escapes into the chimney, *m*, through the openings, *n*. The fire in these furnaces does not rest upon a grate, but lies upon the ground, the old construction for wood being retained, although coal is now used.

The opening at *o*, during the firing, is built up with bricks, leaving a number of openings for the air to pass through the fire, which is piled up as high as, *e*, in the elevation, and sometimes a little higher. *P*, are large fire bricks, forming a sort of bridge or arch over the opening, *e*, and coming close up to the wall, *a*. At this place a groove made in the bridge forms a perpendicular opening, which is closed by the flat brick, *q*. When this opening is closed, the current of flame is more considerable through the upright chimney, *h*, and less through the horizontal flues, *g* and *i*. The former of these currents, however, is diminished, and the latter increased, by removing the brick, *q*, by which a current of cold air descends through the openings below; by means of this brick the heat is increased at top or bottom of the kiln at pleasure, the uniformity of which is of great consequence.

In the plan, part of the upper floor of the kiln is removed to show the direction of the flues; the fourth quarter being left covered with bricks, as when the seggars are piled upon the floor. In the direction of each of these flues every other brick is left out. This gives the upper floor the appearance of being full of holes, and through these holes the flame rises among the piles of seggars. The seggars being of a circular or elliptical form, although piled close together, leave sufficient interstices for the flame to pass through. The piling is commenced at the opposite side of the kiln to the door-way, *f*, and continued till the last pile is raised close to the entrance, which is then closed up with brick till the firing is completed.

The first firing, or that in the biscuit oven for Staffordshire ware, usually lasts from 48 to 50 hours. Rings of Egyptian black clay are placed in the kiln, as trial pieces, by taking out which the biscuit fireman governs his proceedings.

The biscuit, or once burnt ware, absorbs water, and hence it is used without glazing for wine coolers, and for pots for growing flower roots.

The biscuit is painted previously to its being glazed. Some wares are painted by the pencil. Others have the pattern engraved upon copper plates, and the colouring ingredients, which is mostly oxide of cobalt, are ground with oil to form an ink, with which the engraving being filled, an impression is taken as usual by the rolling press, upon tissue paper, previously brushed over with soft soap water; the impression is trimmed with scissors, and applied to the biscuit. As soon as the ware has imbibed the colour, the paper is washed off with clean wa-

ter, and the ink dried in a kiln. Sometimes the outline of a pattern is printed, and it is filled up with the pencil.

The biscuit is then ready to be glazed, either with a raw or frit glazing.

Raw glazes are generally composed of white lead, Cornish stone, and flint ground; to which metallic oxides are sometimes added, they are used for the more common wares.

Frit glazes are in fact ground coloured glass; Lynn sand is the usual basis, which is fluxed either with soda, or with white lead and flints ground.

The glaze ground with water, is made up to the consistence of cream, and the ale pint of slip usually weighs about 32 ounces. As the ingredients are heavy, the slip must be kept stirred, to prevent them from settling. The biscuit is dipped in this glaze, and turned rapidly about that it may lie evenly on the surface; and as soon as it is dry, it is placed again in seggars, which are piled in the gloss oven.

The gloss oven seldom holds more than half the quantity of ware fired in the biscuit oven; as the fire is quickly raised to the height necessary to melt the glaze, and is usually kept fired from sixteen to nineteen hours. Trial pieces, made of raw red clay, are used to govern the gloss fireman's operations.

The choicest articles of pottery are painted, gilt, or printed black, upon the glaze. The painting is performed by means of metallic oxides; black, by the oxides of iron, cobalt, and copper, mixed together; purple or violet, by oxide of gold, and Cassius' purple precipitate of gold; green, by oxide of copper; and blue, by oxide of cobalt. The colours are ground with oil of turpentine, or oil of tar, and laid on with camel hair pencils.

Gilding is performed by grinding gold separated from aqua regis by copper, along with oil of turpentine, and applying it with a pencil or sponge, upon the ware.

Black printing is performed with glue papers, made by pouring out melted glue into very smooth dishes, so that it may lie to the thickness of about an eighth of an inch; these papers, when cold, are cut into the requisite sizes. The copper plate, having the design engraved upon it, is filled with boiled oil, (without any colour to give it the denomination of ink,) and a piece of glue paper pressed upon it; the oil in the strokes adheres to the glue paper, which is then pressed to the ware, on which it in turn leaves the oil. The colours reduced to very fine powder, are slightly sprinkled on the ware, and adhere to the oil; and when the oil is dry, the remaining colour is carefully wiped off with old silk rags, and the ware fired in the enamel kiln.

The enamel kiln is externally from six to ten feet long, and three to five feet wide; it has two, three, or four fire holes, in which wood is burned, and the flame conducted round an iron muffle, which is usually four feet long, two and a half wide, and three high in the centre of the arch.

The articles are carefully placed in this kiln, until the whole is filled, when the mouth of it is bricked up, a small opening being left, with a stopper fitted to it, for inspecting the progress of the firing, the extraction of the trial pieces, and the uniform heating of the muffle, which is extremely difficult, and requires great attention on the part of the fireman. The firing in this kiln usually lasts eight or ten hours.

It is according to these processes that the several kinds of pottery made in Staffordshire are made; they varying only in the ingredients which form the clay, or body of the work, and in the glazes applied to them.

The *common red pottery* is made of brick clay, very slightly fired in the biscuit oven, and glazed transparent with litharge, or black, with galena; this glaze is attacked by acids, and even fat.

Meigh's red pottery is made of four parts of common marle, one of red marle, and one of brick clay, and is glazed with glass and Cornish stone, in equal parts; to which, for a black glaze, is added black manganese. This ware is not attacked by acids or fat, and may be used without any hazard for pickle jars.

Fine red pottery is made of nearly equal parts of yellow brick clay and red Bradwall wood clay.

Burnett's red pottery, from Hallfield colliery marle; by the addition of ochre, their *brown pottery* was formed.

Stone china is made of Cornish stone, Cornish clay, blue clay, and flint; the glaze is white lead, glass, Cornish stone, and flint.

Iron stone china is very strong; its composition is kept secret by Messrs. Mason.

Felspar china is made of Cornish stone, Cornish clay, felspar, and bone ash.

Cream coloured pottery is made of blue clay, Cornish clay, flint, and Cornish stone; some add black clay, brown clay, and cracking clay, with but little flint and Cornish stone. It is glazed with Cornish stone, flint, and a small proportion of white lead.

Blue printed pottery is made with a greater proportion of blue and porcelain clays, and flint, than the cream pottery; and its glaze is made of glass, white lead, Cornish stone, and flint.

Semi China is a ware that approaches to the semi transparency of the oriental porcelain.

Chalky pottery is made from Cornish clay, blue clay, Welsh clay, flint, Cornish stone, white enamel tinged with smalt; to which some add, bone ash and plaster of Paris; the biscuit requires a very strong fire. The glaze of this ware is glass, Cornish stone, flint, borax, refined saltpetre, red lead, purified pearl-ash, Lynn sand, carbonate of soda, and zaffre, fritted by a strong fire, then ground and mixed with white lead, glass, flint, and Cornish stone.

Bamboo ware, or cane coloured ware, is formed of black marle, brown clay, Cornish stone, and shavings of cream coloured pottery; it is never glazed outside, although sometimes the outside is vitrified, the inside is usually glazed with a thin coat of glass.

Wedgewood's jasper pottery is formed of blue clay, Cornish clay, sulphate of barytes, flint, and a little plaster of Paris, tinged with zaffre.

Pearl pottery is only used for choice articles; it is composed of blue clay, Cornish clay, Cornish stone, a little glass, and red lead.

Black Egyptian pottery is made of cream-coloured slip, manganese, and ochre; it is glazed with white lead, Cornish stone, and flint; the inside is washed with white lead, flint, and manganese, to form a glaze for that part.

Drab pottery is formed of blue clay, Cornish clay, Brad-wall wood clay, Cornish stone, black marle, and a little nickel; the inside is glazed with cream colour slip, flint and Cornish clay. Another kind of drab ware is made of the shavings of cream-coloured ware made into slip, and mixed with nickel.

Riley's shining black biscuit porcelain, although not glazed, yet having undergone a high degree of vitrification, has a polished vitrified surface like black coral without any glaze.

Gold lustre ware is made of common red clay; the lustre is given it by laying a slip of soot, or lamp black, and when dry, brushing the ware over with precipitated gold, ground with oil of turpentine.

Silver lustre ware is made with a common cream-coloured ware; glazed with soot, or lamp black, and when dry, brushing the ware over with precipitated platinum, ground with oil of turpentine.

Dr. Leigh, in his Natural History of Lancashire, says, he has seen black lead mixed with red lead run upon a clay near Haigh, into a glaze scarcely discernible from tortoise-shell; and that it was on a whitish yellowish earth, near the same place, that Mr. Dwight made his first discovery of his most incomparable metal.

Oriental Porcelain, or China Ware.

The oriental porcelain, although its forms do not appear so elegant to our eyes as the European, and the paintings upon it are, according to our notions, deficient in taste; yet, in the more essential qualities of infusibility, and bearing sudden changes of heat or cold, it is hitherto unequalled in Europe, although the German porcelain comes very near it.

The oriental porcelain is made from only two ingredients, namely, 1, kao lin, which is a very dry porcelain clay composed of nearly equal parts of silica and alumina: 2, pe tun tse, which appears to be our felspar, or perhaps cleavelandite, which has lately been distinguished from felspar. These are prepared, mixed, and the air bubbles got rid of, as in other pottery wares. The Chinese manufacturers keep the prepared body for a number of years, laying it up early in life for their sons, and working that left them by their fathers.

The Chinese workmen excel in the throwing of their ware upon the wheel, as may be observed in the extreme thinness of some of the articles imported from thence.

It appears that in China, the thrown ware is only dried in the room in which the kiln is built, and then glazed with pe tun tse made into a slip with a ley of fern ashes. After which, it is painted, and enclosed in seggars, and fired in a kiln, which is much smaller than European kilns, being in the shape of an egg set on end, and having only a single pile of seggars in the direction of its axis. The fuel wood is apparently burnt on a grating of bricks made of coarse porcelain, and the air admitted underneath by a long arched vault, as in glass houses. Hence the manufacturing of their porcelain differs in a remarkable manner from the European, which is always fired before it is glazed.

Marbling is a process applied to China ware, by which it seems to be full of cemented flaws. It is called by the Chinese, who are very fond of it, tson tchi; by us, marbled China ware. It is generally plain white, sometimes blue, and has exactly the appearance of a piece of China which had been first broken, and then had all the pieces cemented in their places again, and covered with the original varnish. The manner of preparing it is easy. Instead of the common glaze of the China ware, they cover this with a slip made of a sort of coarse agates, calcined to a white powder. If the marbled China be desired blue, they first give it a general coat of this colour, by dipping the vessel into a blue glaze; and when this is thoroughly dry, they add another coat of this agate slip.

European Porcelain.

This manufactory is little more than a century old, and was introduced in a curious manner; one Bottger, a German lad, was apprentice to a chemist at Berlin, and became acquainted with an alchemist, who undertook to teach him the art of making gold. Bottger, imagining his fortune was made, ran away into Saxony; this was in 1700; his master discovering him, claimed him, but he obtained protectors in Saxony, who wished to profit by his pretended knowledge; he soon discovered that he had been deceived by his instructor: in the course, however, of some experiments for making crucibles capable of bearing an intense fire, he accidentally discovered a composition of earths that formed porcelain by firing. The first porcelain was made at Dresden, in 1706, of a brownish red colour, but in 1709, Bottger, now become a baron, made the first white porcelain, and in the next year, the manufactory at Misnia was established. The manufacture was afterwards introduced into France, and improved by the Reaumur and Macquer, and has since been brought to England, and practised with great success.

Weber has published an account of the Vienna porcelain, having worked there, as well as in the Thuringian manufactory. The following are the compositions used at Vienna.

<i>Gypsum China.</i>	No. 1.	No. 2.	No. 3.
Passau clay, as the basis	10	100	100
Calcined black flints	9	9	8
Plaster of Paris	4	5	6
Broken porcelain	7	8	9

<i>First glazings of gypsum China.</i>			
Calcined flints	8	9	10
Broken porcelain	15	16	17
Plaster of Paris	9	10	11

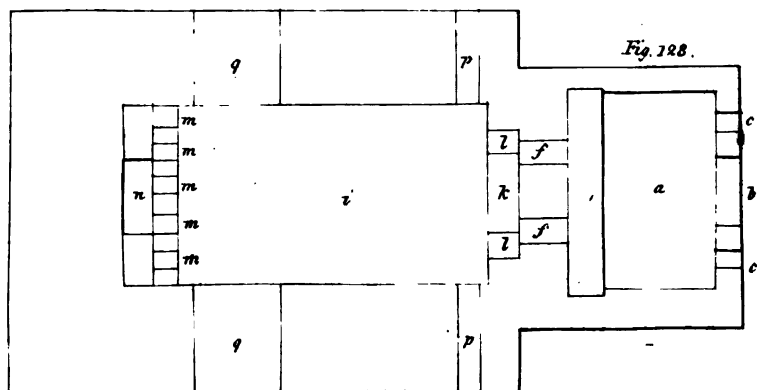
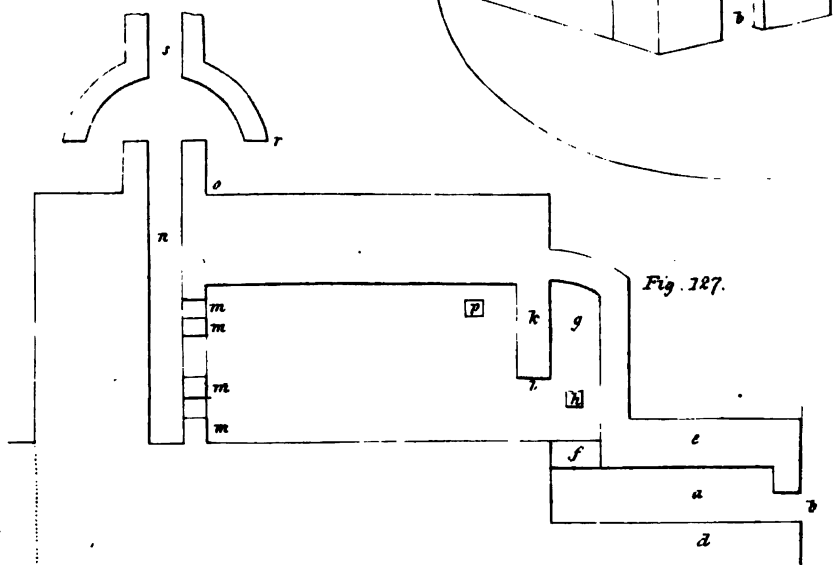
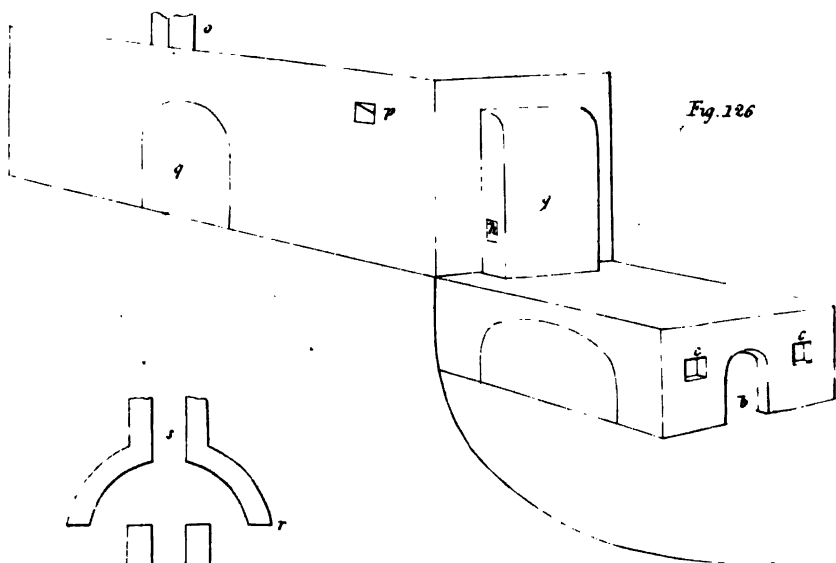
<i>Sand-stone China.</i>			
Passau clay	100	100	
Porlitz sand-stone	20	20	
Chalk	0	5	

<i>First Glazings for sand-stone China.</i>			
Calcined flints	11	1	
Broken porcelain	18	1	
Plaster of Paris	12	1	

<i>Biscuit Ware for Statuary Figures which are not to be glazed.</i>			
Passau clay	50	2	
Calcined flints	10	10	
Plaster of Paris	1½	—	
Calcined pebbles	—	10	

These wares are first baked slightly, then glazed with their first glazing, which is fired with a gentle heat. The second





glaze, composed of equal parts of Passau clay, Porlitz sandstone, and chalk; to each 100 pounds of which is added one-sixteenth of a pound of borax; is then laid on, and the final firing given.

In the Saxon manufactories, the second glazing is said to be formed of felspar, reduced to a slip by water mixed with a little vinegar, and the ware fired for 30 or 36 hours.

Weber has also given draughts of various potters' kilns, and compared the respective qualities, as to fire room, equality of heat throughout the chamber, passage of the flame, draught, and size of the chamber for the seggars.

The Vienna kiln is simply a parallelopiped chamber, ten feet long, six wide, and three feet high, built on the ground, and having at one of the narrow ends, an open hearth for burning wood, with seven openings, six inches square, even with the floor of the chamber, for the flame and heat to pass into the chamber, from which it issues by a short chimney made in the middle of the roof, at the opposite narrow end.

The French kiln is similar to our own, save that, being smaller, it has only three fires around it, and that it has four short chimneys at top.

The Thuringian kiln is of an excellent construction, and a perspective view is represented in fig. 126, a section in fig. 127, and a plan in fig. 128. The fire room *a*, is six feet wide, as many deep from front to back, and one foot and a half high. The fire door, *b*, is two feet wide, and eight inches high; it is arched at top. On each side of the top of this fire door is a small square opening, *c*, with stoppers, by which the fireman examines the state of the fire. The whole of the fire room is usually sunk in a semicircular pit, so that the roof is level with the floor of the laboratory. It has no grate, but the wood is burnt upon a flat hearth of bricks, *d*, one foot thick, and the low arched roof, *e*, of the fire room, is one foot and a half thick, so that the pit is necessarily four feet deep.

The flame of the wood passes through two holes, *f*, twelve inches wide, and eighteen deep, situated at the extremity of the roof of the fire room, into the immediate chamber, *g*, which is three feet wide, and one foot and a half deep. Its floor, in which these holes are situated, is raised three feet from the ground, so that the roof of the fire room in this place, is six inches thick. This intermediate chamber is four feet high, and its top is turned into a quadrantal arch against the front wall of the main chamber, where it is five feet high. The wall is a foot thick, and it has on each side a spy hole, *h*, about eight inches square, fitted with stoppers.

The main chamber, *i*, in which the seggars are piled, has its floor even with the ground; but this floor is constructed three feet thick of brick work, sunk in the earth. The external dimensions above ground, are eighteen feet long, fourteen wide, and eight feet high. The front wall, *k*, next the intermediate chamber, is one foot thick, and has, even with the floor, two openings, *l*, each two feet and a half high, and a foot wide, to allow the passage of the flame out of the intermediate chamber. The space for the seggars is eleven feet long, six wide, and five high, or 330 cubic feet. Towards the back wall is a partition of brick, a foot broad, having a number of holes, *m*, in quincunx, by which the flame issues out into a flue, *n*, which passes through the roof, and is two feet wide, and one deep, terminating in a chimney, *o*, rising three feet above the roof. The side and end walls of the main chamber are four feet thick, and the roof three. *P*, is an opening, of which there is one on each side, towards the front and top of the chamber, for trial pieces to be taken out occasionally; and *q*, is one of the side doors into the chamber, by which the seggars are put in, after which it is bricked up, and a small opening only left to take out trial pieces.

In order to augment the draught, the chimney is surmounted by a dome, *r*, five feet in diameter, internally, from whence a flue, *s*, proceeds, three feet in diameter, and built as high as convenience will admit.

Da Costa's Natural History of Fossils contains an account of earths and stones, which is highly valuable to the potter, as showing the places where they may be found.

Kirwan's Elements of Mineralogy, details the action of fire upon minerals; but although far more practically useful than any of the later systems of mineralogy, yet it does not descend to the minute details given by Da Costa.

Stone Ware.

This is the *poterie de grès* of the French chemists; there are two kinds of it, white and brown, but the former is now scarcely used, in consequence of the preference given to blue and white, and painted pottery for dinner services, notwithstanding the superior strength of the white stone ware.

This white stone, or flint ware, is made of tobacco-pipe clay, reduced to a fine slip, and mixed with a slip of calcined flints. The mixture is then dried on a kiln, and beaten to a proper temper, when it is thrown on the wheel, or moulded in a fly press into the proper forms. The ware being dried is enclosed in seggars, having openings in the sides, and fired for about forty-eight hours; common salt is then thrown into the fire, and being reduced to vapour by the heat, its vapour penetrating into the seggars by the openings on the side, promotes the fusion of the surface of the ware, and thus gives it a polished appearance.

A coarser kind of white stone ware is made of sand instead of calcined flints.

The brown stone ware differs only in respect to the materials, which are a coloured, but equally infusible clay, and sand; it is fired and glazed in the same manner, except that it is not enclosed in seggars, but the kiln is divided into stories by brick floors. There are some clays that do not require the throwing of salt into the fire, but acquire a smooth vitreous surface merely by an increase of the heat, and these clays are preferred by the manufacturer.

The gray Dutch stone ware is superior in strength to the English, and particularly in regard to bearing the exposure to fire.

A kind of stone ware, different from the ordinary ware, is manufactured into retorts and other distilling vessels, which are to be exposed to an intense heat. In this stoneware, a slip of ground vessels, which have failed in the baking, is used in-

stead of calcined flints or sand; and from its greater infusibility the surface is rough.

Crucibles for containing oxide of lead, or glass containing much of that oxide for a long time in the fire, are made of this composition, and rendered extremely close in their texture, by the material being tempered very stiff, and compressed into form in a fly press.

Crucible Ware.

The object of this ware being to stand considerable heat, its external appearance is not regarded.

Crucibles and other chemical vessels, are usually made of raw and burnt clay, made into thick slips, and mixed in certain proportions. Sometimes this mixed slip is formed immediately into vessels, by casting in plaster moulds, or it is dried to a convenient degree, and then either formed into shape by hand, or thrown on the wheel.

Stourbridge melting pots are made by simply moulding the raw clay into shape by the wetted hands, and then leaving them to dry; hence they are usually kept in the fire an hour before they are charged.

For melting metals, black pots are used, which are made of raw clay mixed with ground refuse black lead, not fit for pencils, nor lustre; and the Sheffield pots of this kind, are made of clay and ground stifled coke; these vessels are thrown on the wheel. They bear sudden alterations of heat better than the other kinds of ware, but when salts are melted in them, the charge soon runs through into the fire.

Tobacco Pipes.

This manufacture is of less extent than the other branches of pottery ware; but the furnace, as used by the English tobacco-pipe makers, is of a very peculiar construction, and in some respects superior to the potters' furnace, as having the fuel supported on a grate.

The pipes themselves are made of clay, which being coloured with bitumen only, burns white in the fire. This clay is moistened with water, and beaten with a staff for a long time, until it becomes uniformly moist, and fit for moulding. The pipes being moulded and dried in the air, are then fired.

In some parts of the Continent, the pipes are enclosed in seggars that are cylindrical, in which the pipes are disposed so that the bowls are next the sides of the seggar, while the stems form a pyramid in the centre. In this case, as the seggars are

placed in piles, it is only the lowermost of each pile that has any bottom; the middle seggar of each pile being open at both ends, and the uppermost covered with a conical cap, in which the stems of the pipes are received. Several piles of these seggars are heaped in a furnace similar to the ordinary potters' kiln, but smaller.

In England, the seggar is constructed in the furnace, and is in fact an inner chamber to it.

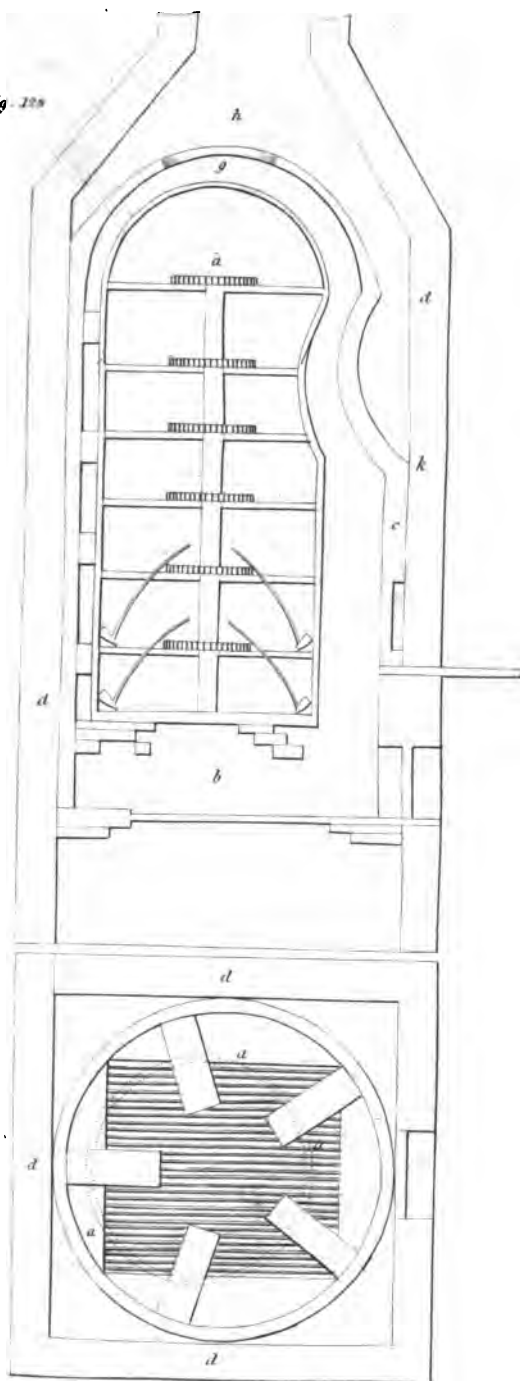
Fig. 129, represents this furnace, which is to be admired for the equality of the heat in every part of the crucible or seggar, in which the pipes to be heated are placed, at the same time that the flame is not permitted to enter so as to soil the articles it contains. This crucible or seggar, *a*, is of a cylindrical figure, terminated at the top by a hemisphere; it is placed over the fire-place, *b*, enclosed within a lining of fire-bricks, *c*, and surrounded by an outer case of brick work, *d*. Between the lining, *c*, and the seggar, is a space of about four inches all round, in which the flame from the fire-place circulates without interruption, except what arises from the numerous supports, which are necessary to sustain the seggar in its proper position; but as these are always placed edgewise to the flame, and are very thin, they cause but little obstruction to its action.

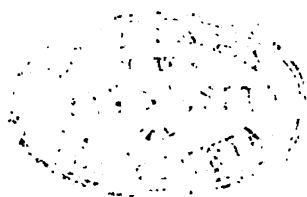
These supports are twelve ribs between the seggar and the lining, which form the same number of flues, as shown by the dotted lines. The ribs are perforated with occasional apertures, to connect one flue with the adjoining; but the principal bearing of the seggar is taken from five piers, formed of bricks projecting one over the other. One of these piers is placed at the back of the fire-place, and other four at the sides, and projecting at the top nearly into the centre of the fire-room, so as to support and strengthen the bottom of the seggar, which rests upon these piers. The spaces between which form the mouths or commencement of the flues, all of which unite in the dome, *g*, of the fire brick linings, and this has a circular opening through it, leading into the chimney, *h*.

The lining, *c*, *d*, of the seggar, is open on one side, to form the door at which the pipes are taken in and out of the furnace; the opening is permanently closed as high as *k*, by an iron plate plastered with fire-clay; above this it is left open, and only closed when the furnace is burning by temporary brick work; when this is removed, the furnace can be filled or emptied through the opening. For this purpose, the seggar has a similar opening in its side. When the furnace is burning, the aperture is thus closed, the workman first spreads a layer of clay round the edge of the opening, he then sticks the stem of broken pipes across, from one side to the other, and plasters the interstices with clay, in a manner exactly similar to the lath and plaster used in building. The whole of the seggar is made in this manner, the bottom is composed of a great number of fragments of pipes, radiating to the centre; these are coated with a layer of clay at the circumference, a number of the bowls of broken pipes are inserted into the clay, then other fragments are placed upright, to form the sides of the seggar. The ribs round the outside, which form the flues, are constructed in the same manner, as is also the dome, *g*, of the fire-brick lining; by this means the seggar is made very strong, but at the same time so thin, as to require but little clay to construct it, and is less liable to split by the heat, than a vessel formed of thicker materials. This method might be advantageously applied in other cases, where a very thin vessel or lining is required for a furnace.

The pipes which are to be baked are arranged within the seggar, the bowls resting against the circumference, and the other ends supported upon circular pieces of clay, *h*, which are set up in the centre for that purpose. Six small ribs are made to project inwards all round the crucible, at the proper height,

Fig. 129





to support the different ranges of pipes, without having so many resting upon each other, as to endanger their being crushed by the weight. By this mode of arrangement, the furnace is made to contain 50 gross, or 7200 pipes.

These require from seven to nine hours to be burned, and the heat is at first brought on gently, and afterwards increased to the full heat required for baking this species of pottery. The fire is regulated by a simple kind of damper, applied over the aperture in the dome, *g*, of the fire-brick lining. This is a mixture of horse-dung, sand, and pipe-clay, well worked together, and spread in thin layers upon coarse brown paper. A sheet of this being laid over the hole in the dome, so as to cover more or less of it, will give the means of increasing or diminishing the draught, and consequently the heat of the furnace.

Bricks.

The art of brick-making consists chiefly in the preparing and tempering of clay, and in the burning of the bricks; and the quality of the ware depends very much upon the right performance of these operations.

The earth proper for making bricks is a clayey loam, neither abounding too much in argillaceous matter, which causes it to shrink in the drying; nor in sand, which renders the ware heavy and brittle. As the earth before it is wrought is generally brittle and full of extraneous matter, it should be dug some time before it is used; that by being weathered, it may be sufficiently mellowed, and thus facilitate the operation of tempering. For good bricks it should always have one winter's frost, but the longer it lies exposed, and the more it is turned over and wrought with the spade, the better will be the bricks.

The tempering of the clay is performed by the treading of men or oxen, and in some places by means of a clay mill.

The moulding of bricks is a very simple operation, and requires very little skill, unless it be to make the greatest number in the shortest time, and the day's labour of a handy workman, employed from five in the morning until eight at night, is calculated at about 5000. The clay is brought to the moulder's bench in lumps somewhat larger than will fit the mould. The moulder, having dipped his mould into dry sand, works the clay into it, and with a flat smooth stick strikes off the superfluous earth. The bricks are then carried to the hack, and there ranged with great regularity, one above the other a little diagonally, in order to give a free passage to the air. The hacks are several yards long, and usually made eight bricks high, and wide enough to be shifted, which is done by turning them, and resetting them more open; and in six or eight days more they are ready for the fire.

Bricks in this country are generally baked either in a clamp or in a kiln. The latter is the preferable method, as less waste arises, less fuel is consumed, and the bricks are sooner burnt.

The kiln is usually thirteen feet long by ten feet and a half wide, and about twelve feet in height. The walls are one foot two inches thick, carried up a little out of the perpendicular, inclining towards each other at the top. The bricks are placed on flat arches, having holes left in them resembling lattice work; the kiln is then covered with pieces of tiles and bricks, and some wood put in to dry them with a gentle fire. This continues two or three days before they are ready for burning, which is known by the smoke turning from a darkish colour to transparent. The mouth or mouths of the kiln are now dammed up with a shinlog, which is pieces of brick piled one upon another, and closed with wet brick earth, leaving about it just room sufficient to receive a fagot. The fagots are made of furze, fern, or heath, and the kiln is supplied with these until its arches look white and the fire appears at top, upon which the fire is slackened for an hour, and the kiln allowed gradually to cool. This heating and cooling is repeated until the bricks be thoroughly burnt, which is generally done in forty-eight hours. One of these kilns will hold about 20,000 bricks.

Clamps are mostly in use about London. They are made of the bricks themselves, and generally of an oblong form. The foundation is laid with place bricks, that is, the driest of those just made, and then the bricks to be burnt are built up, tier upon tier, as high as the clamp is meant to be, with two or three inches of breeze, or cinders, from whence the ashes have been sifted, strewed between each layer of bricks, and the whole covered with a thick strata of breeze. The fire-place is perpendicular, about three feet high, and generally placed at the west end; and the flues are formed by gathering or arching the bricks over, so as to leave a space between each of nearly a brick wide. The flues run straight through the clamp, and are filled with wood, coals, and breeze, pressed closely together. If the bricks are to be burnt off quickly, which may be done in twenty or thirty days, according as the weather may suit, the flues should be only at about six feet distance: but if there be no immediate hurry, they may be placed nine feet asunder, and the clamp left to burn off slowly.

Coke has been recommended as a more suitable fuel than either coal or wood for this manufacture, both with regard to the expense and the proper burning of the bricks, for if this substance be applied, the flues or empty places of the piles, as well as the strata of the fuel, may be considerably smaller; which, since the legislature calculates the tax on bricks by the measurement of the clamps, is no small consideration; and as the heat produced by coke is more uniform and more intense than what is produced by the other materials, the clamp of bricks has a

better chance of being burnt perfect, throughout the whole clamp.

There are many varieties of bricks, manufactured about London, under the several names of place bricks, gray stocks, red stocks, malm bricks.

Fire bricks are also made, which bear an intense heat without melting. Of this kind are Windsor bricks, made of a red clay from Hedgerley, near Windsor; these bricks are cut or ground nearly as easy as chalk; Stourbridge bricks are, on the contrary, extremely hard, like stoneware, but of a uniform texture and dark colour. Welsh fire clumps resemble ordinary bricks, and are of a very coarse texture.

Tiles and Coarse Pottery.

Tiles differ only from bricks in their shape; but they are always burnt in kilns; which generally resemble potters' ovens, but no seggars are used; the kilns being divided into stories by brick floors, upon which the tiles are piled in the same manner as the stoneware kilns.

Common articles of pottery, as chimney pots, garden pots, pans, pipkins, and such like articles, formed either by hand, or on the wheel, are burned in similar kilns, and some of these wares are glazed, by a slip of litharge, either alone or mixed with black manganese; this glaze is so much acted upon by vinegar, salt, and even fat, that, however averse a person may be to have the legislature interfere in matters of trade, they must acknowledge the propriety of its being prohibited.

Delft Ware.

This is, in fact, only common red pottery enamelled; the ware being first covered with a thick coat of opaque white enamel, coloured with oxide of tin, and then painted with other enamel colours.

Before the invention of European porcelain, Delft ware was its substitute; and the Dutch manufacturers endeavoured to counterbalance the clumsiness of the form, by the pictorial excellence, employing the most celebrated artists. Hence, although the manufacture of it has ceased, yet the specimens of it that remain are sold at very high prices, and valued as reliques of the ancient native arts of Europe.

English Alum.

The greatest alum mine in England is at Whitby, and is of alum slate. The stratum of alum slate is about 29 miles in width, and disposed in horizontal beds; the upper part being the richest, and five times more valuable than that which is taken 100 feet lower.

The slate is burned by breaking it into small pieces, laying a bed of furze, brush wood, and cinders, on the ground, and

piling the slate upon it to the height of about four feet. Fire is then set to the fuel, and fresh slate thrown on the pile, until the heap is raised to the height of 90 or 100 feet, and 200 feet square at bottom. If the fire grows too fierce, its rapidity is checked by throwing on the places slate broke into very small pieces and moistened. On an average, 150 tons of calcined alum slate produce a ton of alum.

The calcined slate is washed four times successively, in pits which usually contain about 60 cubic yards: the water being passed through the most exhausted slate first, and through new slate last: remaining on each for a day and a night. The ley is drawn off into cisterns to settle, and afterwards reduced in quantity by heating in large leaden boilers, set on a gentle slope, upon iron plates.

The pans are filled two-thirds with the mother liquor of the crystallizing cisterns, and one-third of fresh made ley, and evaporated, until, in the secret language of the manufacturers, it weighs 36 pounds.

The alum makers' weight was considered a great secret, and passed hereditarily in families, or was sold for considerable sums of money: in the same manner as supposed secrets are still sold in many of our manufacturing towns, and even in London, although they have been repeatedly described in print, so that the buyers may be said not to buy a secret, but to pay, and very dearly too, for their neglect of reading works on their respective arts.

The alum makers' weight is only a statical mode of ascertaining the specific gravity of the leys. A stoneware half-pint bottle is taken and weighed. It is then filled with rain water and weighed again, and a lead or brass counterpoise made to it. The weight of the water which it contains is divided into eighty parts, which are called indifferently penny weights, or pounds, and a pile of weights are adjusted to these denominations; so that the penny weights or pounds that a liquor is said to weigh, in the alum and copperas works, means so many eightieth parts above the specific gravity of water.

The strength of the ley above-mentioned is therefore 1.45, and at this period kelp ley, weighing two pounds, or 1.025 is added in sufficient quantity to reduce the alum ley to 27 pounds, or 1.3375. The ley is then run off into settling cisterns, and from thence to crystallizing cisterns. When the ley is very red, urine is added to reduce it, as well as kelp ley.

After standing four days, the mother water is pumped off into the boilers; the alum crystals are slightly washed, drained, and then dissolved in the smallest possible quantity of boiling water, and the ley run off into large casks, where it remains for a fortnight. The casks are then taken to pieces, and the roched alum is found in a solid mass, with a cavity in the centre. Seventy-three tons of kelp are generally required for crystallizing 100 tons of alum; or, instead of kelp, about 22 tons of muriate of potasse from the soap boilers, or 31 tons of black ash, may be used for the same purpose, and indeed with more advantage,

as the muriate of iron is an uncrystallizable salt, and therefore less apt to foul the alum or impregnate it with iron. Hence, these are used by many manufacturers.

French Alum.

The pure sulphate of alumine does not crystallize without the admixture of potasse or ammonia; to introduce these alkalies, our own manufacturers use kelp, black ash, and urine; but the French have introduced the use of the sal enixum, or sulphate of potasse of the manufacturers of aqua fortis or nitric acid, that of the sulphate of potasse, which is the residuum of the oil of vitriol houses; and that of the sulphate of ammonia prepared from rough bone spirit, saturated with oil of vitriol; to these may be added the sulphate of ammonia prepared from ammoniacal liquor of the gas works.

As these articles are of different prices at different places, and also as they are not always of the same degree of power, it is necessary to ascertain the quantity of alum that they will yield with the alum liquor of the works.

For this purpose 2 ounces of a fair average specimen of the salt is ground in a mortar, and 48 ounces, that is to say, three pounds of alum liquor, thoroughly saturated, and being generally the mother water of some liquor that has been crystallized, is added; the mixture is heated till it boils, and immediately covered up and set by in a cellar to crystallize.

The crystals are carefully collected, placed upon a filter, left twenty-four hours to drain, then washed half-a-dozen times with a saturated solution of alum, drained each time for an hour; then dried with blotting paper, and at last weighed.

The pure sal enixum, or sulphate of potasse of the aqua fortis makers, generally produces nine ounces, or four times and a half of its own weight of alum.

The sulphate of potasse from the oil of vitriol makers varies very much and produces from one ounce to three of alum, or from one-half to one and a half its own weight.

The sulphate of ammonia from bone spirit produces twelve ounces of alum, or six times its weight.

The impure sub carbonates of potasse, or the different kinds of kelp, vary greatly, as do also the impure muriates of potasse.

It is usual in France to employ both sulphate of potasse and sulphate of ammonia, if they can be procured at a reasonable price; but the manufacturers cannot always obtain the latter.

The use of sulphate of ammonia is indeed more expensive than that of an equivalent crystallizing quantity of sulphate of potasse, but this greater expense is compensated by the saving of fuel and labour. This saving depends upon the solubility of sulphates of ammonia being much greater than that of sulphates of potasse. Hence the use of sulphate of ammonia as a crystallizer in alum works, allows it to be added to a very high charged alum liquor; by which means an abundant separation

of small crystals of alum takes place immediately, without any fire, but this effect cannot be obtained by the use of sulphate of potasse, which takes too much water to dissolve it. However, the solution of this salt may be used to dissolve the sulphate of ammonia, and by this means one-fifth of sulphate of potasse may be used along with sulphate of ammonia, without its being necessary to increase the quantity of water to be added to the alum liquor, and thus obliging the manufacturer to boil away the overplus. It is however proper to warm the liquor to 68 degrees Fahrenheit, and then add the solution of sulphate of ammonia; crystals of alum soon begin to separate, and on the crystallization being finished they are to be washed.

When sulphate of ammonia cannot be obtained at a reasonable price, or the cheapness of the other crystallizers lead to their use, then it is proper to dissolve the sulphate of potasse in water kept boiling, and to pour this into the alum liquor, boiled as high as possible, and also hot, then to cool the mixed liquors quickly, to cause the alum to crystallize in small crystals. Another method of using the sulphate of potasse is to grind it very fine, and to add it gradually to the alum liquor by means of a hopper, with a very small opening at bottom. By this means the necessary quantity of sulphate of potasse may be added without the addition of so much water as would otherwise be necessary; the sulphate of potasse becoming united with the sulphate of alumine into alum as fast as it dissolves in the water.

The mother waters and the washings are used to pass through the alum ores, and form fresh alum liquor, until they become too highly charged with sulphate of iron, when they may be used for the manufactory of copperas or green vitriol.

A great object in managing alum is always to dissolve it in the smallest possible quantity of water, as in roching it for sale; for every time that alum is dissolved in a large quantity of water, for the purpose of re-crystallizing it, a sub-sulphate of alumine separates in form of a white powder, which is calculated at two per cent. on the re-crystallized alum.

If alum is dissolved in a quantity of water so as to produce a solution at 25 or 30 degrees of Baumé, or a specific gravity of 1.196 or 1.244, the crystals are smaller, more regular, and fetch in France a higher price, by one-fifth, under the idea that they are purer, whence they are called alun fin; and begin to be used by the French dyers instead of the Italian alum.

Some French alum is made from clay dried, ground very fine, and exposed to the vapour of sulphuric acid, in chambers similar to those used in the manufactory of sulphuric acid itself. In this case kelp is usually added in the first instance to

the clay, before it is exposed to the action of the sulphuric acid, and thus the double sulphate, or alum, is formed at once. This is afterwards washed out of the clay, as from an ore, boiled down and crystallized as usual. This is a more simple method than the common, but it has no advantage in a commercial view.

[Curaudau has lately recommended a process for making alum without evaporation. 100 parts of clay and five of muriate of soda are kneaded into a paste with water, and formed into loaves. With these a reverberatory furnace is filled, and a brisk fire is kept up for two hours. Being powdered and put into a sound cask, one-fourth of their weight of sulphuric acid is poured over them by degrees, stirring the mixture well at each addition. As soon as the muriatic gas is dissipated a quantity of water equal to the acid is added, and the mixture stirred as before. When the heat is abated, a little more water is poured in; and this is repeated till eight or ten times as much water as there was of acid is added. When the whole has settled, the clear liquor is drawn off into leaden vessels, and a quantity of water equal to this liquor is poured on the sediment. The two liquors being mixed, a solution of potash is added to them, the alkali in which is equal to one-fourth of the weight of the sulphuric acid. Sulphate of potash may be used; but twice as much of this as of the alkali is necessary. After a certain time the liquor, by cooling, affords crystals of alum equal to three times the weight of the acid used. It is refined by dissolving it in the smallest possible quantity of water. The residue may be washed with more water to be employed in lixiviating a fresh portion of the ingredients. As the mother water still contains alum with sulphate of iron very much oxidized, it is well adapted to the fabrication of Prussian blue. This mode of making alum, is particularly advantageous to the manufacturers of Prussian blue, as they may calcine their clay at the same time with their animal matters, without additional expense: they will have no need in this case to add potash; and the presence of iron instead of being injurious, will be very useful. If they wished to make alum for sale, they might use the solution of sulphate of potash, arising from the washing of their Prussian blue, instead of water, to dissolve the combination of alumina and sulphuric acid. *Ure's Chem. Dic. Art. Alum.*

A practical chemist of Manchester in England, Dr. Warwick, has adopted the following method for making alum:—take pipe clay and concentrated oil of vitriol in the proportions of 112 pounds of the former, and 72 pounds of the latter; pulverize the clay finely, and mix it into a stiff paste with

the oil of vitriol; make the paste into balls of 6 or 8 pounds each, and sprinkle them over with a little of the dry pulverized clay. Put the balls thus prepared into cylinders of the same form and dimensions as those represented in fig. 104, and close up every aperture, except a small one for the escape of moisture; then expose them to a strong heat for 6 or 8 hours; withdraw the lumps from the cylinder, break them in pieces, and expose them to the air for three or four days. Take 6 cwt. of this mixture and lay it into a leaden vessel, capable of holding four hundred gallons. Pour as much water upon it as will cover it, and stir it occasionally for two or three hours. Then fill the vessel and stir it well. Let the insoluble parts subside, and evaporate the clear liquor in a leaden boiler, until it have a specific gravity of 1.250, when boiling hot, then dissolve as much sal enixum (what remains in the retort after the distillation of nitric acid from nitrate of potash and sulphuric acid,) as will raise the specific gravity to 1.310. The liquor is then allowed to cool and crystallize. The freedom of the alum from iron is obtained in this way, will depend upon the purity of the clay in this respect. The iron obtained from this source may be precipitated from the solution before concentration, by the prussiate of potash, and the Prussian blue, thus formed, be reserved and dried for sale.

Another process for the manufacture of this important salt, is carried on in connexion with the manufacture of oil of vitriol. The product of the combustion of sulphur with nitrate of potash and pipe clay, contains, in fact, a considerable portion of alum ready formed; but by exposure to the air and moisture, the whole of the sulphur which remains in the clay becomes acidified, and unites with the clay. The sulphate of potash formed by the union of a portion of the sulphuric acid, formed in the combustion with the base of the nitre, answers the purpose of a pure alkali in acidifying the crystallization, to which it is usual to add the sal enixum, from the distillation of nitric acid as above. The alum is dissolved out by leaching or otherwise, and the salt crystallized from the concentrated solution. A large proportion of the alum manufactured in the United States, is obtained in this way. The writer is not particularly acquainted with the details of this process; but the foregoing, he believes, is substantially correct.]

Most alum contains more or less sulphate of iron, although seldom more than one-tenth per cent.; yet this small quantity produces perceptible effects in dyeing; hence Dr. Thomson thinks it might answer to dissolve clay, perfectly free from iron, in sulphuric acid, and crystallize the solution by the addition of the usual salts.

Italian Alum.

In the alum works at Tolfa the ore is blasted, then separated from the rock that adheres to it, and calcined in furnaces similar to lime kilns, for five or six hours. The calcined ore is laid in heaps upon a paved floor, surrounded with ditches, out of which, water is flung upon it daily for six weeks. The water is then evaporated by boiling, and crystallized by cooling in large pans.

At Solfatara, a concealed volcano near Puzzuolo, sulphureous and sulphurous acid fumes are constantly discharged from the ground; the former condense into native sulphur, or rough brimstone; the latter act upon the lava rocks, and combining with the alumine form efflorescences; the washings of these efflorescences, and also of the calcined ore, similar to that of Tolfa, which is also found in the neighbourhood, is evaporated in leaden cisterns, sunk in the ground, which being here of the temperature of 104 degrees Fahrenheit, no fuel is required. The alum made in this manufactory is very pure.

Alum is greatly used in dyeing and calico printing, being one of the principal preparatives for the colours. It is also the basis of several lakes, or body colours used by painters. Tanners also use it to harden their hides, and tallow melters to harden tallow; in medicine it is also used with views nearly similar.

Alum is a triple salt, consisting essentially of sulphuric acid and alumine, rendered soluble in water, sometimes by potasse, sometimes by ammonia, according to the materials used in its manufacture: these salts are however so similar in their appearance and properties that they are not usually distinguished, except by dyes.

The ammonia sulphate of alumine, or the sulphas aluminico ammonicus of Berzelius, is stated by him to consist of $N \cdot H^o S \cdot + Al \cdot S \cdot^3$, and its atomic weight to be 2,861,540. According to Dr. Thomson its composition is $3 (S \cdot Al \cdot) + S \cdot Az H^3 + 25 H \cdot$, equal to 57,000.

The potasse sulphate of alumine, which is that commonly sold as alum, or the sulphas aluminico kalicus cum aquâ of Berzelius, is stated by him to consist of $K \cdot S \cdot^3 Al \cdot S \cdot^3 + 48 (H \cdot O \cdot)$ and its weight 11,870,770. Dr. Thomson makes it, $3 (S \cdot Al \cdot) + 8 \cdot K \cdot + 25 (H \cdot)$ equal to 60,875; so that he supposes it differs only from the ammonia alum in having an atom of sulphate of potasse substituted for the atom of sulphate of ammonia, which is imagined to be combined with the three atoms of sulphate of alumine and twenty-five of water.

The potasse alum is rather more soluble in water than the ammonia alum; for 100 parts of water at 60 degrees Fahrenheit, will dissolve 14 parts three-fourths of potasse alum, and only 9 parts one third of ammonia alum.

Soda Alum.

The sulphate of alumine may also be crystallized, by adding soda, or soda salts, to the ley of alum slate.

It cannot be distinguished in appearance from the common alums, and if pure undergoes no alteration by exposure to the air; when impure it is easily crushed between the fingers, and its surface soon becomes powdery in the air. 100 parts of water dissolve no less than 327 of soda alum, so that it will be far more

convenient for dyers and calico printers, when it is brought into the market, but it has not hitherto been manufactured on a large scale.

Acetate of Alumine.

This is prepared in large quantities for the calico printers, generally by pouring a solution of 70 pounds in potash alum into a solution of 100 pounds of sugar of lead, and decanting off the liquid portion.

It is now sometimes prepared for inferior work, by adding a saturated solution of quicklime in pyroligneous acid, so diluted with water as to have the specific gravity of about 1.050, to a solution of alum, in the proportion of four gallons of the acetate of lime water to each eleven pounds of alum employed; and separating the sulphate of lime that falls down, by straining off the liquor.

Acetate of alumine is employed instead of alum, as a preferable preparative in dyeing and calico printing.

MAGNESIA.

Some chemists rank this among alkalies, but it is nearly totally insoluble in water; it is the *calcined magnesia* of the shops, so called because it is prepared by heating the ordinary magnesia alba in a crucible, until the carbonic acid and water of the latter is expelled.

Calcined magnesia, as thus obtained, is a white powder, but its proper colour seems to be green; for when stones or earths have this colour, the analytical chemist shrewdly guesses them to contain this earth; and medical men have observed that magnesia exhibited as a medicine frequently produces green stools.

Calcined magnesia is of no use but in medicine; it is supposed by the theorists to be the oxide of a metal they call magnesium. Berzelius imagines it to be Mg : and its weight equal to 516,720; but Dr. Thomson supposes it to be Mg : and its weight 2,500.

Magnesia Alba.

This is obtained from Epsom salt, by adding to its solution in water a ley of purified pearl-ash.

Its composition varies much, according to the quantity of water, and the heat that is employed. Berzelius analyzed a specimen, and found 100 parts of it to contain 44.75 of magnesia, 35.77 of carbonic acid, and 19.48 of water; hence he considers it as $3 Mg: C: + Mg: Aq$, and calls it hydro carbonas magnesiæ, its weight being 4,618,343. Dr. Thomson is inclined to think it is $3 Mg: C: + 4 Mg: H$, equal to 22,750; but Mr. Phillips states it, in his Pharm. Lond. to be the anhydrous carbonate, or $Mg: C$: and its atomic weight 42 of his scale, equal to 5,250 of Dr. Thomson's scale.

Magnesia alba is called magnesiz subcarbonas by the English medical faculty, and is used as a laxative and absorbent.

Epsom Salt.

This salt was originally crystallized from the mineral water of Epsom, near London; and is the *sulphate of magnesia* of the southern theorists, but called, by Berzelius and the northern chemists, *sulphas magnesicus*.

A large quantity of it is manufactured from sea water, as stated in p. 360; but as the salt thus made is mixed with muriate of magnesia, it grows moist in the air; Dr. Henry, to avoid this defect, manufactured it by several other processes as follow.

He exposed the caustic magnesian lime prepared by burning or calcining the stone, called magnesian lime-stone, to the atmosphere for some time, and passed the slaked lime through a fine wire sieve.

When the acetous or pyroligneous acid is to be employed, the quantity of magnesian lime, or of its hydrate, sufficient to saturate a gallon of the acid, must be first ascertained, and twice as much of the magnesian lime is then added, or else of its slaked hydrate, as is necessary for the saturation. After about four hours, the supernatant liquor is decanted, and may be applied to any of the purposes to which acetate of lime, which is the substance held in solution in the liquor, is adapted. The undissolved portion is chiefly magnesia. This magnesia is calcined at a low red heat, with free access of air, to burn away completely the tarry, resinous, and vegetable colouring matter with which it is contaminated. On any quantity of the calcined magnesia, reduced to a fine powder, and diffused through water, in the proportion of half a pound to each gallon of water, oil of vitriol, diluted with five or six times its weight of water, is poured. Instead of adding oil of vitriol to the calcined magnesia, copperas may be dissolved in eight times its weight of water; and to the solution a quantity of the calcined product, finely pulverized, and equal in weight to about one-third part of the sulphate of iron, may be added, assaying by means of any of the known chemical tests for iron, a portion of the liquor first cleared by standing; and if the whole of the sulphate of iron proves not to be decomposed, more of the calcined product is mixed with the liquor, until the decomposition of the sulphate of iron or copperas is complete.

By either of these processes a solution of sulphate of magnesia is obtained, which is crystallized by evaporation, there being added, when the liquor has been boiled down to one-third, either magnesia alba in the proportion of about one ounce to every five wine gallons of the liquor, or calcined magnesia in

the proportion of about an ounce to every ten wine gallons of the liquor.

In like manner, when the nitric or muriatic acid may be used, first determining, by a previous experiment, how much of either of the acids is sufficient for the saturation of a given weight of the slaked magnesian lime. This quantity of either of the acids, previously diluted with ten or twelve times its weight of water, is then mixed with twice as much of the slaked magnesian lime as is necessary to saturate the acid.

The magnesian lime may also be acted upon by means of muriate of magnesia, or the bittern that remains after the common salt and Epsom salt have been separated from sea water. A quantity of the bittern, containing a known weight of solid muriate of magnesia, as obtainable by evaporation to dryness, is added to an equal weight of the slaked magnesian lime, the supernatant muriate of lime is decanted, and the sediment washed repeatedly with water till the water comes off tasteless. Oil of vitriol diluted with water is then added to the sediment, till there is a slight excess of acid, which excess is saturated by magnesia alba, and the solution crystallized as usual; or, instead of oil of vitriol, sulphate of iron in the proportion of three parts of copperas to one part of the sediment, may be used. By the use of this bittern, or muriate of magnesia, not only the magnesia which formed a constituent part of the magnesian lime is obtained; but also a farther quantity of magnesia, precipitated from the bittern by the calcareous part of the magnesian lime.

Any quantity of sal ammoniac may be dissolved in ten times its weight of hot water, and as much of the slaked magnesian lime as is equal to the weight of the sal ammoniac added; clear liquor being decanted, and submitted to distillation, yields ammonia water, and the sediment from which the liquor has been decanted, washed repeatedly with water, and acted upon, either with oil of vitriol diluted with water, and with a solution of copperas, yields Epsom salt.

Oxymuriatic acid, or chlorine, may also be employed, by regulating the proportion of oxymuriatic acid, or chlorine, to the slaked magnesian lime, by adjusting the quantity of materials which are used, to afford the gas to the quantity of magnesian lime employed to condense the gas. The general proportion is, for every bushel of common salt, fifty-six pounds of oil of vitriol, at 1·850, forty wine pints of water, and forty pounds of finely ground manganese. And, for every bushel of common salt, at least twenty-eight pounds of the slaked magnesian lime, may be placed in a dry state, in a proper receiver, or suspended in water. The liquid oxymuriates of lime

is decanted off, the insoluble part washed repeatedly with water, and afterwards acted upon in the manner already mentioned, either with dilute sulphuric acid, or with sulphate of iron.

Dr. Henry considered oil of vitriol, whenever it can be obtained at a reasonable price, to be much more fit than copperas, for the purpose of preparing Epsom salt.

Epsom salt is, according to Berzelius, $\text{Mg: S:} + 10 \text{ H H:}$, and of course 2,643,390; but Dr. Thomson makes it, $\text{Mg: S:} + 7 \text{ H:}$, equal to 15,375.

Floating Bricks.

Bricks so light as to swim upon water are a very ancient manufactory, although not yet introduced into this country. Pliny informs us they were made in his time, at Marseilles in France, Colento in Spain, and Pitane in Asia; and Sign. Fabroni has lately made them in Tuscany.

The earth from which they are manufactured, is that called mineral agarie, guhr, lac lunz, or fossil meal, and that used by Sign. Fabroni, was dug near Castel del Piano, in the Siennese; 100 parts of it contained 55 of silica, 15 of magnesia, 14 of water, 12 of alumine, 3 of oxide of lime, and one of iron. It is not fusible, but loses one eighth of its weight in the fire, without any diminution of its bulk.

Bricks made of this earth, either baked, or unbaked, float upon water, and even one-twentieth of clay, may be added to it, without causing them to sink. They do not imbibe water, and cement well with mortar; the baked bricks differ only from the unbaked, by becoming sonorous. A brick seven inches long, four and a half broad, and one eight-twelfths thick, weighed only 14 ounces one-fourth, while a common brick, of the same size, weighed five pounds, six ounces, and three-fourths. They conduct heat very badly.

Sign. Fabroni recommends these bricks for cooking-places in ships, and to line floating batteries. He thinks the turrets, mentioned to have been built on the ancient ships, may have been constructed with them; and that they were perhaps used in the celebrated ship sent by Hiero, to Ptolemy, as it is said to have had several porticoes, baths, halls, and other apartments, ornamented with mosaic work, agates, and jasper.

METALS.

Metals have, in all ages, formed the favourite subjects on which chemists have laboured; indeed, at one time, the knowledge of them constituted the whole of what was understood by the name of chemistry. Their extensive usefulness in the arts, and their intimate connexion with the civilized state of mankind, justify this favouritism. Without bronze or steel, for forming cutting instruments, how imperfect would be the state of the arts; without gold or silver, as common scales of value, how imperfect would be the state of commercial transactions. Gold, indeed, is found in the sands of rivers, but its purity must be ascertained: the other three necessities of civilization, require preparation by chemical operations.

Seven metals have been known for ages, and as this number coincided with that of the planets then known, and the principal cultivators of chemistry were the priesthood, they mystified the laity by using the names of the planets as nicknames of the metals.

The use of gold and silver, as commercial mediums of valuation, and their great value, joined with the numerous chemical analogies between the metals in general, led the chemists, in the earlier period of the science, to suppose that they all consisted of a few elements conjoined in various proportions, and hence to attempt the problem, of changing metals of inferior value, into those of greater value, by altering the proportion of the supposed elements. That they are compounds of a few elements in different proportions, is still probable, but the metals resist the action of such powerful agents, without alteration, that the changing of them into one another, is a problem utterly hopeless of solution by any train of reasoning; chance alone can resolve it.

The number of the metals has been greatly increased of late years, by the analytical chemists, and is by some stated at forty-two; but some of these are little better than hypothetical assumptions, and two of the number, namely, potassium and sodium, are so different from every thing that a practical man would call a metal, that nothing but the rage of the day for the invention of new metals could have prompted their insertion in the list; such indeed was this rage, that hydrogen gas was pronounced to be a metal, just as at present, every organic principle that can be combined with an acid, is called a new alkali.

Metals are the heaviest of bodies, being from six to twenty-one times as heavy as water. Their great use, arises from the generality of them being either capable of being spread out by the hammer or rollers, or being drawn into wire, or capable of being cast into form, by melting and running into moulds; there are indeed some, that are intractable by any of these methods, but their combinations are of great use as colours, or for other purposes.

Of these metals, quicksilver is always in England in a melted state; but in the northern countries sometimes solid, cadmium, copper, gold, iridium, iron, lead, nickel, osmium, palladium, platinum, silver, tin, and zinc or spelter, may be rolled into plates, or drawn into wire; regulus of antimony, arsenic, bismuth, and tellurium, may be cast; but cerium, chromium, cobalt, columbium, manganese, molybdenum, rhodium, tungsten, titanium, and uranium, require a heat for their fusion, which is at present

beyond that of our furnaces; but some of them are brought into use by their admixture with other metals.

Mines.

Some of the metals are found as natives of the earth, but the generality are in a combined state with other principles, and must be separated by art. These combinations are called the ores of the metals, and either form great beds in the earth, or, which is most usual, are found in cracks of the earth, called veins.

When the ores are found in beds, or large masses, underground, they are extracted in the same manner as rock salt, already described in p. 355, and of which a draught has been given in fig. 111. Sometimes this kind of mine is worked in the manner of a stone quarry, by merely cutting out the ore, leaving pillars or walls to support the roof; or the covering of earth being removed, the ore is cut out like slates from their beds, in steps or banks.

As a specimen of the manner of extracting the ores which are found in veins, the mode of working the Cornish mines may be described.

The veins, or, as they are provincially called, lodes, generally run in an east and west direction. These lodes vary considerably in breadth, and the average may be taken at from one foot to four feet; for in some cases they are only a barley corn in width; while in Nangiles mine the lode is in some places 30 feet wide; and for about the length of 20 fathoms, in Relistian mine, the lode is even 36 feet wide. The width of a lode is by no means regular, for it will vary from six inches to two feet in the space of a few fathoms.

No instance has yet occurred of any lode having been cut out in depth. The deepest mine now at work is Dolcoath; so named from an old woman, Dorothy Koath, who lived on the spot when the working of the mine commenced. This mine is about 235 fathoms deep, and as the counting house belonging to it is 360 feet above the level of the sea, the mine extends 1050 feet below it; which is probably deeper below the level of the sea than any other mine that has been worked. Grenver and Oatfield have lately stopped working, or they would excel Dolcoath in depth, for they are cut down 240 fathoms.

The east and west lodes are cut by others, called cross courses, which run north and south, and do not cause an interruption to the lode, but alter their position, so that the miners must search generally to the right hand to find them again;

it is very rarely that left handed heaves occur. These heaves occasion much trouble to the miners; in Huel Peever it took a search of forty years to recover the lode.

When adventurers determine to work a mine, and have agreed with the proprietor of the soil respecting his share or dish, three points are to be considered: 1. The discharge of the water that may be met with. 2. The removal of the deads, that is the barren rock and rubbish. 3. The raising of the ore. The first object, therefore, is to cut an adit, or underground passage about six feet high and two feet and a half wide, from the bottom of some neighbouring valley up to the vein. This is a considerable expense, but still in the end the most economical mode of getting rid of the water, which must otherwise be raised by pumping, an operation which must still be resorted to in regard to that part of the mine which is below the upper part of the adit. Some of these adits are of great length; the adit into which the steam engine of Chace-water mine pumps its water is not less than 24 miles long; it is the deepest adit in the county, and flows into one of the creeks of Falmouth Haven.

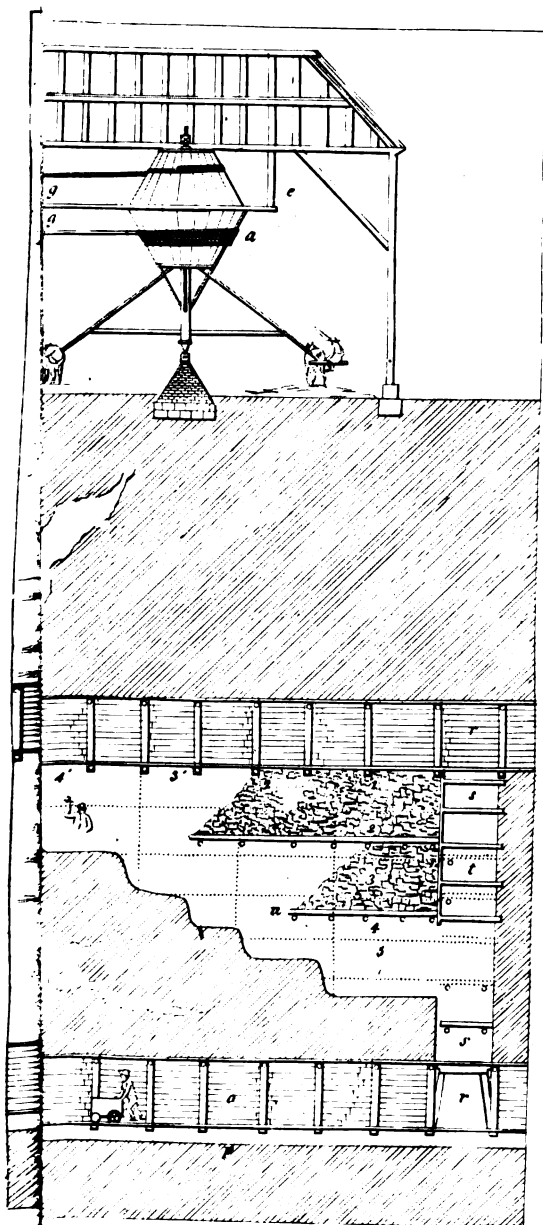
As soon as the vertical opening, or shaft, is sunk to some depth, a whim is erected to bring up the deads and ore in baskets, called kibbuls, one of which goes down empty while another comes up full. The whims are turned by two horses, and it is estimated that these horses save to the county the labour of 10,000 men. As the lode never runs down perpendicularly, it is necessary to cut galleries, called levels, generally about two feet wide, and six high, in a horizontal direction. Other shafts are also sunk which traverse the several levels, or a special communication is made between only two galleries by a particular shaft called a wins. When several levels run parallel to each other through the rock, or country as it is called, they are made to communicate by other levels, called cross cuts.

For keeping the workings from being inundated, each mine is furnished with a chain of pumps, descending from the adit level to the bottom of the mine, or sump, as it is called, all these pumps are worked by a single pump rod, moved by steam engines: whose aggregate power is supposed to be at least equivalent to the labour of 40,000 men. The water is raised by these pumps, each of which receives the water brought up by the one immediately below it, until it reaches the adit, through which it flows by a gentle descent to the surface.

Fig. 130 represents the section of a continental mine, which differs in some slight respect from our Cornish mines.

A, is the drum of the whim used for drawing up the ores, by means of the buckets, *b*, which are attached to it by ropes or chains, one bucket going down

Fig



as the other comes up. The horses which turn these drums are trained to stop at a signal given to them, and to turn back and move in a contrary direction. The ropes move over the pulleys, *c*, and are thus brought over the well or shaft of the mine.

As it is sometimes necessary to stop the descent of the bucket instantaneously, an apparatus called a bridle is used. Two long beams, *d*, *e*, are placed one on each side of the drum, *a*; each has attached to it a concave log that closely embraces the convex surface of the drum, *a*. These beams are brought, when necessary, close to the drum by means of the two iron rods, *f*, which are fastened to the cylinder, *g*. The cylinder itself is turned by the rods, *h*, *i*; and thus a labourer, by means of the lever, *k*, which moves the vertical rod, *i*, is able to bring the beams, *d*, *e*, close to the drum, and stop its motion, in spite of all the efforts of the horses, or the weight of the descending load.

L, represents the plan of the mouth of the mine, which is divided by boarded partitions into two and sometimes three divisions. In the first, *l*, is placed the pump, the perpendicular ladder by which the miners descend, and sometimes pipes for forcing fresh air into the mine, or extracting foul air from it by machinery. The other two divisions are for the buckets; if they are not actually divided by boards, great care is necessary to prevent the sway of the buckets from entangling the ropes. *M*, is the bucket division of the shaft, here represented perpendicularly, which is the common direction, but in some mines the shaft is inclined. Each method has its advantages. The inclined shaft is generally carried on in the vein itself, so that the ore extracted is to be placed against the cost of making the shaft; and, as the buckets are made to run on rail ways, and the weight is supported by the wheels, the friction is not very great. *N*, is another shaft at a distance, with a ladder, being only intended as a passage into a distant part of the mine, and for ventilation.

It is to be observed, that the drawing of the galleries, and their distance from each other, are not in proportion to each other, for want of room in the plate.

O, is one of the principal galleries, leading to the main shaft of the mine; *p*, is a gutter or drain, running along the gallery, and leading to the well, or sump, *q*. *R*, are cross galleries, by which the main galleries are connected, or the miners search for ore.

In working a vein *under foot*, a scaffold, *s*, is let down three or four feet below the floor of the cross gallery, *r*, and as many miners as can work side by side, descend upon it, and cut out two parallelopipedons, *1'*, *2'*, about three feet high, and six or eight yards long. As soon as the miners are arrived at *3'*, more miners are set to work, but on a lower level, *t*. These cut out the second step, while the first set work on the upper level. As soon as these miners have cut out the second step, *2*, a third gang is set to work on a still lower level, and thus a kind of stairs is formed, on which a great number of the miners may work at once, without incommoding one another, and as the ore has always two of its faces free, it is the easier to cut or blast.

In this method of working, there is a necessity to support the roof of the vein; and if, as is commonly the case in the continental mines, the vein stones or deads are not brought up to-day, but left in the mine, there is an equal necessity to find some place for them. For these purposes strong scaffolding is constructed behind the miners as fast as they proceed in their work, and the dressers of the ore throw the rubbish on these scaffolds, where it is left.

In working a mine *over head*, a miner at the bottom of the shaft, *m*, cuts out a parallelopipedon, *1'*, about five feet high, and six or eight yards long. When this is achieved, another miner is placed behind him, and the first proceeds forward, to *2'*, *3'*, *4'*, the second miner brings down the ore from a higher level, *2*, a third from a still higher level, *3*, and so on, until the vein is exhausted.

Each of these methods have their respective advantages. In working a mine under foot, the miner stands on his work; he cuts straight before him, without any inconvenience, and is not exposed to the ore falling upon him. As the way by which he entered the vein is shut up by the rubbish thrown behind him, he gets out by the bottom of the stairs he forms, and it is also by this passage that

the ore is carried out. On the other hand, it requires a considerable quantity of large timber to construct the scaffolding.

In working over head, the miner is more fatigued, and as the ore falls on the rubbish on which the miner stands, some of the ore is lost amongst this rubbish.

The pumps for extracting the water from our English mines, are usually worked by steam engines; but in Hungary, and the east of Germany, they are worked by a column of water, as expending less water than a mill wheel, and therefore more economical, even if a stream to turn a thirty feet wheel, and a fall of twenty fathoms or more, can be obtained. These machines were first brought into use by Hoell, in the Schemnitz mines, about 1749, and their use has gradually spread westward, and it is in consideration, to employ them in the Hartz and Saxon mines. Their construction, being merely mechanical, does not belong to this work.

Mechanical Preparation of Metallic Ores.

After the ore has been dressed, by knocking off, by means of hammers, the vein-stone adherent to it, a farther preparation is necessary to fit it for fusion; the machinery for this purpose is brought to great perfection in Germany, although Humboldt allows that the Spaniards in America prepare their ore still finer than the Germans.

Fig. 131, represents a paddle wheel for washing ores. *A*, is a water mill wheel, turning the arbor, *b*. *C*, is a hollow trunk into which the ore is thrown. *D*, a trough by which a stream of water is made to run into the trunk, *c*. *E*, are bars of iron that form the paddles by which the ore in the trough is moved about, that the stream may wash off the adherent clayey or earthy matters. *F*, a trap which is opened occasionally to allow the ore when it is sufficiently washed to fall into the canal, *g*, through which the water forces it into the cistern *h*.

Fig. 132, is a section of a stamping mill, for reducing ores to powder; as they are generally very hard, the bottom of the mortar is composed of a bed of the ore itself. *A*, is one of the pestles, or stampers, of which there are usually from six to fifteen in the same trough or mortar. *B*, is a groove in the stamper, in which the wipers, *c*, work, in order that it may be raised perpendicularly. *D*, are friction rollers, to facilitate the motion of the stamper. *E*, the lower end of the stamper, armed with iron. *F*, the arbor of the mill wheel, furnished with the wipers, *c*. *G*, is the trough of the stamping mill, or mortar, *h*, that part of the trough in which the ore being stamped is lodged. *I*, is the trough by which a stream of water is made to run into the stamping trough. *K*, is the trough by which the water runs off, carrying with it such of the ore as is stamped sufficiently to pass an upright screen into the trough, *l*, from whence it is carried by the stream to the shaking tables, or elsewhere.

M, is a chest, or hopper, into which the dressed ore is flung, and from whence it descends by a hole in its bottom, along the inclined plane, or slide, *n*, into the stamping trough.

Bucket sieves are sometimes employed, in which a labourer can sift rich ores in a tub of water. A lever, from whence the bucket is suspended by an iron rod, and a counterpoise to the bucket and ore is used, in order that the labourer may easier raise the bucket by means of a handle, and place it on the table. This mode of preparing ore is only used when the ore is very rich and water extremely scarce.

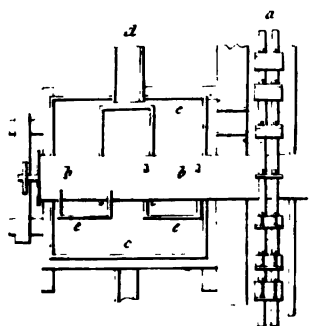
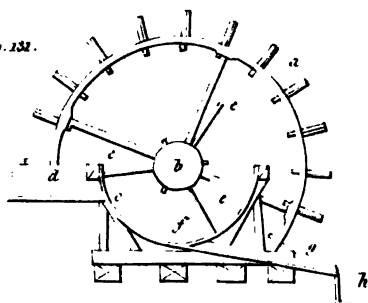


Fig. 131.



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 feet

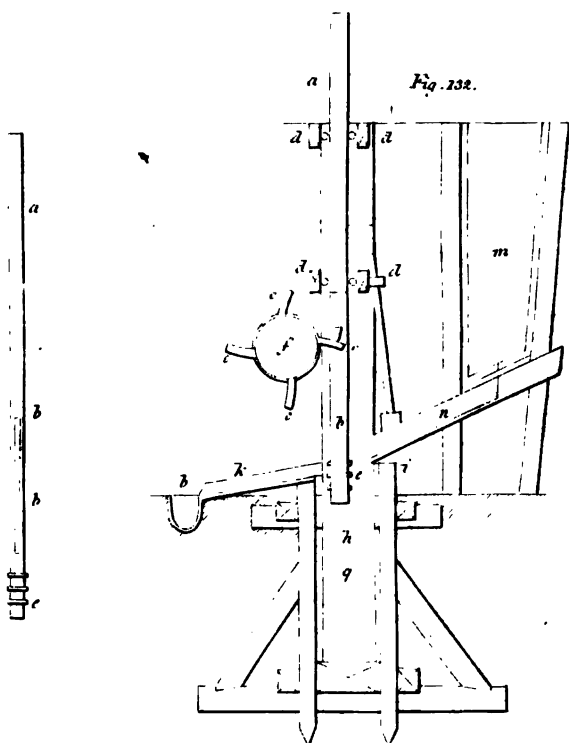
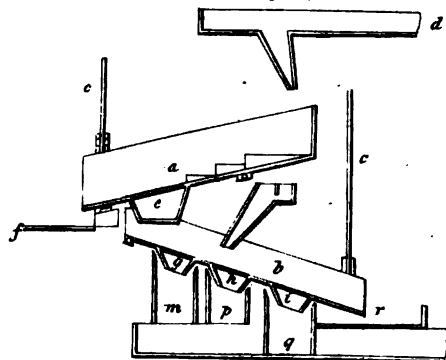


Fig. 132.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 feet

Fig. 133



0 1 2 3 4 5 6 7 8 9 feet

Fig. 134

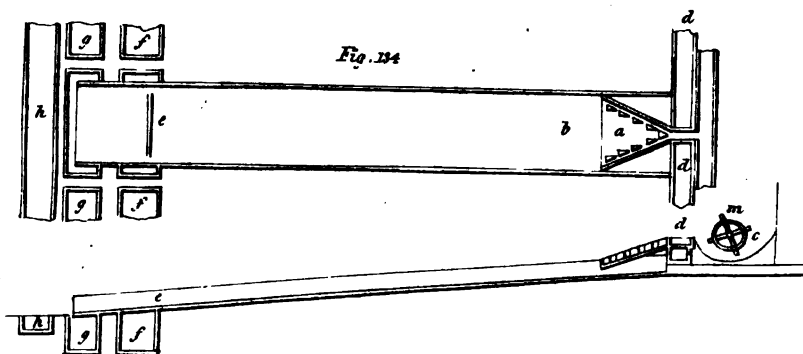
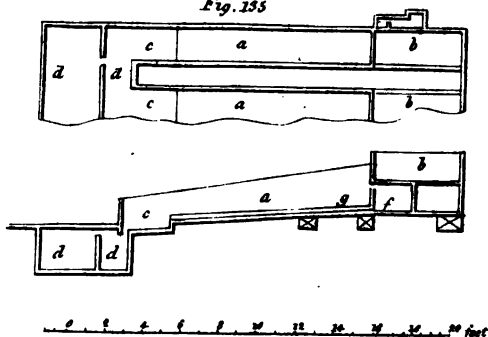


Fig. 135



Another kind of sifting machine is sometimes used in the Saxon and Hartz mines when water is scarce. A slide is generally used, down which the smaller pieces of dressed ore are flung from the mouth of the mine, when situated higher up a hill. By pulling down the upright stem, the trap of the slide is opened, and the ore falls into a chest, the bottom of which is formed of a grating; and it then immediately falls into the water of the cistern.

The chest moves on a horizontal axis, sliding between two upright beams. The workman having shaken the chest in the water of the cistern, raises it by means of the handle, and having stopped its falling by putting in a block of wood, shoots the ore, by means of a lever opening a small trap in the side of the chest, upon the table where the dressers work.

The smaller grains of the ore which pass the grating of the chest, settle in the water of the cistern, from whence, by opening a plug in its bottom, they are conveyed, by the water rushing out, into other machines, where they are farther prepared.

Fig. 133, represents a turning over screen, used in the Hartz mines, principally for the screening of lead ore holding silver. *A, b*, are two narrow chests, the lower end of each of which is connected by an iron rod, *c*, with the arm of a small lever, which is moved up and down by wipers placed on the arbor of a mill wheel. By this means the lower ends of the chests, *a, b*, are raised and let fall alternately. *D*, is a trough by which a stream of water is led to the chests, to assist in the screening of the ore. The ore to be screened being broken small is flung on the upper part of the chest, *a*, and a stream of water directed upon it; the ore which cannot pass the coarse screen or cast iron grating, *e*, slides along to the table, *f*, where it is examined by the dressers, and separated by hand, either to be stamped, dry or wet, or thrown amongst the rubbish, or for immediate smelting. As to the ore that passes the coarse screen, *e*, it is carried by the water over the two brass wire sieves, *g, h*, and an iron wire sieve, *i*, which form the bottom of the chest, *b*. The ore that passes through the sieve, *g*, is called fine sand, and is collected in *m*; that which passes through the sieve, *h*, coarse sand, and is collected in *p*; both of these sands are afterwards washed upon the washing tables. The very coarse sand that passes through *i*, into *q*, is washed in a bucket sieve, as is also the large pieces that will not pass through any of the sieves of the chest, *b*, and is collected in the chest, *r*. This apparatus is very simple, and useful in separating ore into different finenesses.

Fig. 134, represents a fixed washing table, called a sweeping table, used in the Hartz mines, for separating the clean ore ready for the furnace from the other ore. Two or more of these tables are usually placed side by side in a washing house. The stamped or screened ore is brought by the trough, *c*, and to hinder it from settling, the water is continually agitated by the small paddle wheel *m*; from this trough it flows with the water over the triangular space, *a*, and is spread by means of the stops on the sides of this space equally over the table, *b, c*; a stream of clear water being also brought by means of the trough, *d*. Towards the bottom of the table is a slit, *e*, which is kept close during the flowing of the water, which carries off the earthy matter into the trough, *h*. When the table is filled with ore, that below, *e*, is swept into the cistern, *g*, and the slit, *e*, being opened, the ore on the upper part of the table, is swept through the slit into the cistern, *f*.

Fig. 135, represents a simple fixed washing table, for the preparation of ore which is too fine for the screen, and yet too large for the sweeping, or moving washing tables. The chests, *a*, or *tombs* as they are called, are about three yards long, twenty inches wide, and their sides of the same height; their bottom lies on a gentle slope. At the upper part is a kind of flat ledge, *b*, on which the ore to be washed is placed, and under this ledge is a trough, *f*, by which a stream of water is let over the table and runs off through holes in the end boards of the chest, *a*.

The workman throws a parcel of ore upon the raised ledge, *b*, at the upper end of one of the three tables that constitute a set, and letting on the water and keeping it at different heights, by stopping or unstopping the holes in the

end boards, he transfers the ore as it settles in different parts of the first table into the second, and from thence to the third, and thus obtains clean ore of different qualities and sizes by a single operation, according to his skill in washing; while the still finer particles are carried off by the water, into the troughs, *d*, which are continued to a great length, with many turns and returns, so as to be kept in a small compass and of different widths; the broader troughs having stops put half way across them, in order that the ore may be thoroughly separated into different parcels according to its various specific gravities.

Fig. 136, represents a longitudinal section, in the direction, *y, y*. Fig. 138, of another kind of washing tables, which are moveable, and called shaking tables. Fig. 137, is the transverse section, in the direction, *x, x*; fig. 138, of the same; and fig. 138, the plan.

The table, *a*, is about four yards long, and five feet broad; the edge and end boards rise about eight inches. This table is not fixed, but hangs by means of four chains, one at each corner, *b*; when the table stands still it hangs inclining towards the feet.

Above and behind the table is a fixed platform, *c*, which supports a triangular inclined plane, *d*, with boards on the sides, and several blocks of wood, *e*, which serve to divide the stream of water and spread it equally over the table. Above this inclined plane, *d*, is fixed the chest, or hopper, *e*, into which the screened ore is thrown. The bottom of this chest slopes, and is separated into two parts by a sluice, *f*, which has a hole, *g*, in its bottom part. The screened ore is thrown into the upper division, *h*, the lower division, *i*, remaining empty. A trough, *k*, passes over these tables and brings a stream of water, which flows through the two pipes, *l*, by one of them being directed into the filled division, *h*, and by the other into the empty division, *i*. The ore is carried by the stream into the empty division, and from thence is spread evenly over the table, and would be carried by degrees off the table; but while this is going on, the head of the table receives a stroke from the machinery, *m*, which pulls it forwards, and this stroke being intermitted, the table returns to its former station, receiving, however, in striking against the block, *n*, a violent shock.

The machinery, *m*, that produces this motion of the table, is composed of an arbor, *o*, furnished with wipers, *p*. These wipers lay hold of the end of the lever, *q*, by which the roller, *r*, is turned round a little; the end of the lever, *s*, is brought forward, and consequently the horizontal beam, *t*; this beam being thus moved, is driven against the head of the table, *a*, and as the table returns to its place it strikes against the block, *n*.

The object of this motion and shaking of the table is, first, to separate the stony particles that had adhered to the ore, by communicating to them unequal velocities, in proportion to their different specific gravities; and, secondly, to bring the particles of the ore, as being the heaviest, towards the head of the table.

In washing different kinds of ores on these tables, attention must be paid to several circumstances. The table is hung at different slopes, from one to seven inches. The water is also let on, sometimes in a very slender stream, and sometimes very flush, to the amount of two cubic feet by the minute. The number also of shocks given to the table varies from fifteen to thirty-six in a minute; and it is pushed from its original hanging from an inch to six inches, by which the shock itself is varied in its strength. The screened ore, called gross sand, requires, in general, less water and a less slope than the fine or clammy sand.

When it is ascertained that the ore is completely washed, and that the water that runs off contains none of the ore, the water is allowed to pass on along the trough, *k*, while the clean ore is taken out; but if there is a suspicion that the water still contains some particles of the ore, the trough is stopped, and the water is allowed to run off into a trough at the foot of the table, where it deposits those particles which are again submitted to the process of washing.

By the skilful combination of these means of stamping and washing ores, as practised in the German mines, very poor ores

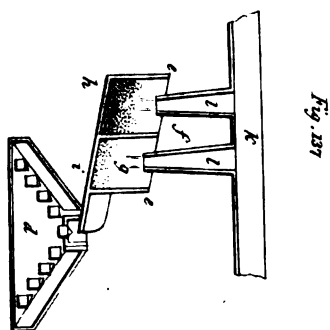


Fig. 137

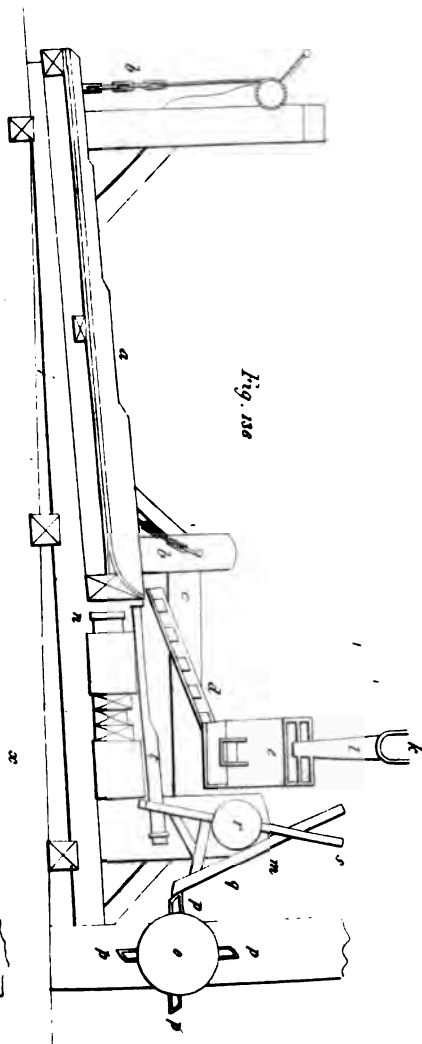


Fig. 136

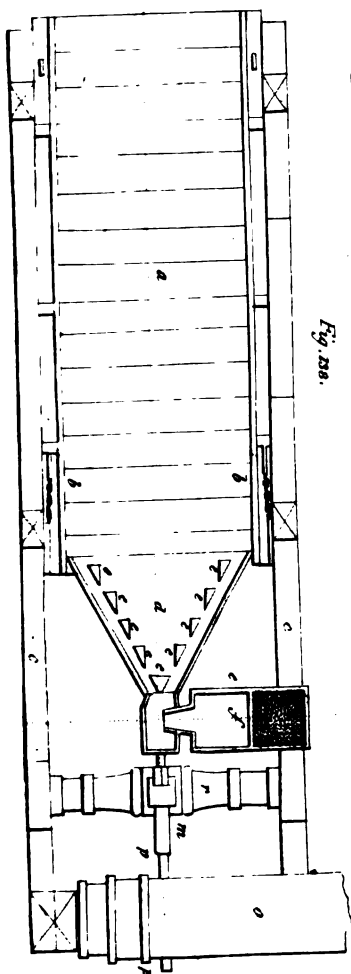


Fig. 138.



are rendered profitable, such as those of the two mines of Frankscharn and Altenau, in the Hartz, which raise annually 876,200 cwt. of ore. This, by stamping and washing, is reduced to 111,367 cwt. of clean ore, sorted into four qualities; and these by smelting yield 35,582 cwt. of lead, or its equivalent of litharge, 84 cwt. 7 of silver, and 49 cwt. 1 of copper.

For washing on a small scale, the chemist should be provided with a trough, about a foot long, an inch and a half broad at one end, and three inches at the other, where it should be three quarters of an inch deep. The clay, sand, pounded ore, or dirt, is mixed with about four times its quantity of water, the trough kept very loose between two fingers of the left hand, and some light strokes given on its broad end with the right; by which means the heaviest particles are brought to that end, and the lightest may be separated by inclining the trough and pouring a little water on them.

Chemical Preparation of Ores.

There is another preparation which most ores undergo before they are smelted, in order to get rid of the volatile substances, which by uniting with the metal would render it impure; these volatile substances are generally sulphur or arsenic. As this preparation consists in exposing them to a gentle and long-continued heat, it is called roasting of the ores.

Some minerals are roasted only once; others, particularly copper ores, a number of times, even fourteen or more. These repeated roastings are rendered more effective than a single long-continued roasting by melting the ore between the roastings in order to distribute the volatile substances equally throughout the mass.

Some ores, as copper pyrites, bituminous copper ore, and the like, are roasted in immense uncovered heaps.

Fig. 139, represents an uncovered heap of this sort, some of which are composed of several hundred tons of ore. The bottom of the heap, *a, b*, is formed of two or more layers of fuel, the rest being only ore. The largest pieces of ore are thrown towards the hollow space, *c, d*, which is left partly as a chimney, and partly to light the fire, by throwing down some lighted fuel, and the smallest pieces towards the surface of the heap, which is sometimes beaten close together, and sometimes covered with earth, *e*. The fuel being lighted, the roasting is continued by the sulphur or bitumen for a long time, sometimes for years together, fresh ore being supplied at one end of the heap, and that at the other carried away. Care is usually taken to stop any cracks that may happen at the sides, and oblige the vapours to pass out at the top only of the pile. Holes are frequently left at the top, in which a part of the sulphur is collected, and removed before that part becomes so hot as to dissipate it. When the ore is very combustible little or no fuel is necessary, and the heap is lighted at top. In some cases these heaps are placed under sheds, to hinder the rain or wind from extinguishing the fire.

Fig. 140 represents a section, and fig. 141, a plan, of a plain kiln, for roasting ores, which is generally made of a small size, the place for the ore being about eight feet from side to side, six from front to back, and four deep, surrounded by walls, *a*, the floor slopes down from the back to the front, and is covered with a layer of fuel, upon which the ore is thrown. When the furnace is full, as the air is admitted at *c*, in the front wall, the ore is covered at top with fine stamped ore, *d*, to force the sulphur to pass through the openings, *e*, in the back wall, into the room, *f*, where the sulphur fixes, and the incoercible vapours pass off by the chimney. In the lower Hartz, a kiln of this kind, containing about 2000 cwt. of ore, and 730 cubic feet of wood, will in four months produce 30 cwt. of sulphur.

Fig. 142, represents a plan of part of a row of roasting kilns, which consist only of a back and side walls, but are open to the front; and fig. 143, is a section of the same. These kilns are usually built in opposite rows under a shed; the fuel is laid at bottom, the coarse ore thrown upon it, and covered with fine ore; by which the vapourized sulphur is forced through the opening, *c*, in the back wall, *d*, and condensed in rooms similar to those represented in fig. 140, and 141.

When the ore contains a less proportion of sulphur or bitumen, and of consequence will not maintain the heat of the pile; as also when the ore is stamped fine, and will not allow the passage of air through it, then a proper furnace must be erected for the purpose, with a distinct room for the fire.

Fig. 144, represents a vertical section of a reverberatory furnace used in Germany for roasting such kinds of ore; fig. 145, is a horizontal section of the upper part, on the level of the floor of the condensing rooms, *e*, and fig. 146, is another horizontal section on a lower level, just above that of the grate of the fire room, *a*.

A, the grate on which the fuel is burned, the flame of which traverses the roasting rooms, *b*, and *c*, and passing up the pipe *d*, it goes through the condensing rooms, *e*; the smoke and vapours escape by the chimney, *f*. A space, *m*, is left between the main body of the furnace, and its external wall, which serves partly as a receptacle for the roasted ore when drawn hot out of the furnace, and partly to prevent the spreading of the vapours, which are carried off by the hood, *n*. *O*, are openings in the bed of the furnace to breathe out the moisture when first built.

The ore to be roasted is first placed on the roof, *g*, of the condensing rooms, *e*, where it is dried by the heat, and then shovelled down the hopper, *h*, into the upper roasting room, *c*, after which the hopper is closed, and the ore is spread evenly over the floor of the room, *c*, by a rake, introduced at the opening, *i*. Here it remains one or two hours, and is gradually heated, and is then pushed by the rake upon the floor of the lower roasting room, or altar, as it is called, where it generally begins to burn, and requires but little fuel in the fire room. Afterwards the fire must be increased to volatilize the last portions of sulphur and arsenic which remain; when the roasting is finished the ore is drawn out by the doors, *k*. The operation usually lasts twenty-four hours.

The greatest part of the sulphur and arsenic in the ore is condensed in the rooms, *e*, from whence it is taken out occasionally by the workmen entering at the doors, *l*.

In some of these furnaces a drying room for the ore is placed between the roasting room, *b*, *c*, and the condensing rooms, *e*, which form the third story of the furnace, as at Lautenberg; this construction has the double advantage of exposing the wet ore to a greater heat, by allowing the heat to enter from the fire by two or more wide mouth hoppers, always open; and of the condensing rooms being cooler, as heated farther from the fire.

Fig. 139

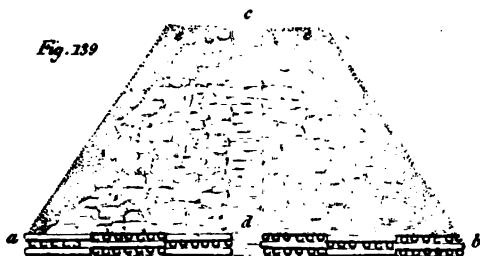


Fig. 140

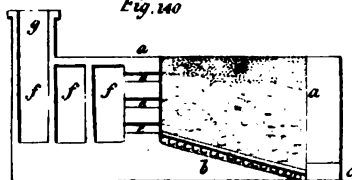


Fig. 141

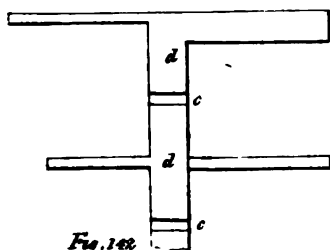
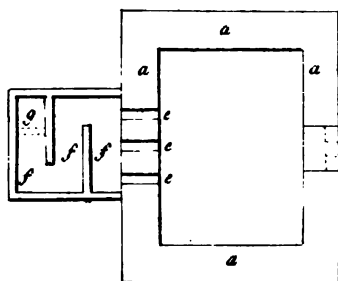


Fig. 142

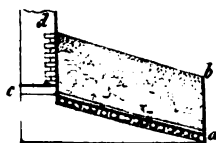
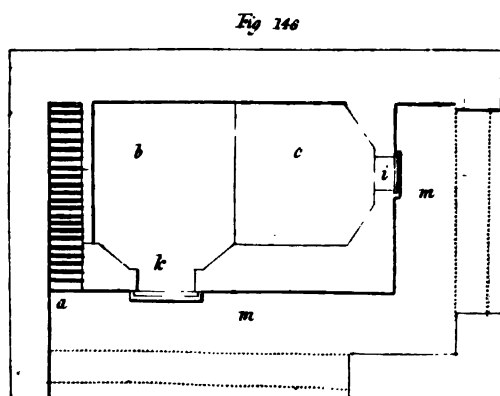
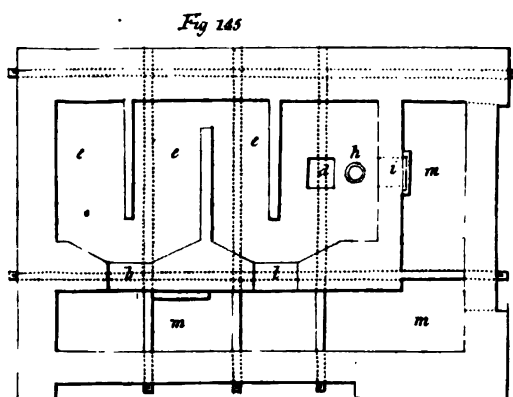
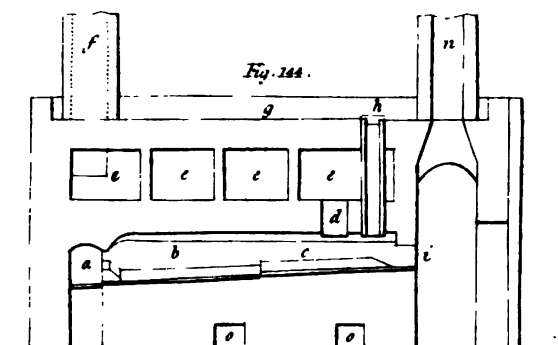


Fig. 143

0 2 4 6 8 10 12 14 16 18 20 feet





0 2 4 6 8 10 12 14 15 feet



Blowing Machines.

The prepared ore is smelted either in blast or draught furnaces; the blast furnaces vary in height, and are distinguished into high or low furnaces; the draught furnaces are generally of the reverberatory kind, but attempts have been made of smelting iron ores in air furnaces, surmounted by a very high chimney, to cause a sufficient draught without the use of blowing engines, the fuel and ore being thrown into the very deep fire room alternately.

The blast of a fall of water, and that of bellows moved by machinery are frequently used even in the largest metallurgic establishments; but lately there has been substituted for these blowing machines the action of pistons, moving in large cast-iron cylinders, or that of a bell alternately raised or depressed in water.

Fig. 147, represents the section of a blowing machine of the first kind, with a regulating cistern. This machine of two cylinders of cast iron, in each of which a piston, *p*, furnished with leathers, *v*, is made to move by the action of an arbor, *a*, turned by a water wheel, instead of which agent the crank of a steam engine is usually employed in England.

B, is an elbow crank, which moves the rod *b*, *c*, that by means of the crank, *d*, communicates motion to the bent iron axis, *d*, *f*; *i*, are the piston rods, jointed in the middle, and running in the grooves, *k*, by which means an up-right action is produced. The cylinder, 1, is represented as filling with air by the piston being drawn up; in consequence of which motion the valves, *s*, in the bottom of the cylinder communicating with the air vault, *c*, under the frame work of the machine, are raised by the pressure of the atmosphere to admit the air into the cylinder, 1, and the valve, *t*, through which the air enters into the blast pipe, 3, is shut by its own weight. The cylinder, 2, is shown as descending and forcing out the air through the valve, *t*, of course the inspiring valves, *s*, are shut, having fallen by their own weight.

This machine appears at first sight very simple and efficacious, but it has its inconveniences: 1, the blast is unequal, being sometimes stronger than at other times: 2, the friction of the pistons is very considerable.

The first inconvenience is remedied by one or other of the three methods already pointed out in p. 59; the third method is represented in the figure, as being adopted with the machine as there drawn.

5, is a large bell, of wood or iron, constructed in a deep cistern of water, *q*, so as to be immovable. The cistern is filled with water up to the level, *n*, when the machine is not at work; but when it begins to work, the level within the bell is depressed, and that in the cistern raised to the levels, *m*, by the blast of air that rushes from the cylinders through the blast pipe, 3, into the bell, 5. The difference of this level, *m*, from that of *n*, is shown by the gauge, *l*, *m*, composed of a hollow copper floating ball, and an iron stem, with an index at the top, pointing to a graduated scale on the frame work; and measures the force of the blast, which is thus equalized, and conveyed by the second pipe, 4, to the furnace itself.

By this means the blast is indeed equalized, but the friction of the pistons cannot be got rid of.

Fig. 148, represents the floating bell, or hydraulic blowing machine. *A*, is a wooden or cast-iron bell, which is raised and lowered by the rod, *b*, connected with some moving power, as a steam engine or water wheel, *C*, is a cistern of water in which the bell is suspended, and moves up and down. *D*, is a valve which opens by the pressure of the atmosphere, and allows the air to enter and fill the bell as it is raised up by the moving power, which is the state in which it is represented in the drawing. *E*, is the first portion of the blast pipe, by which the air is forced on the descent of the bell, and the consequent falling down of the valve, *d*, into a regulating cylinder, as figured in fig. 147, No. 5. *F*, is the valve or trap, which prevents the return of the blast into the bell, as it rises. *G*, are rollers, to guide the bell as it moves up and down, and preserve its perpendicularity.

The blast from these machines, as well as that from bellows or other contrivances, is generally directed into the fire itself; but in some cases it is also applied to the substances submitted to the action of the fire; and in others it is not applied to the fire, but only to the substances which are being worked, as in refining copper and silver.

As the air is saturated with water in the bell of the regulating cistern and in the floating bell, the moisture is prejudicial in some cases: hence their use has been abandoned, and the blast from the pistons thrown directly into the furnace.

LEAD.

LEAD is the most common of the metals, and is usually combined naturally with sulphur, which is got rid of by various operations.

Raw lead, is that obtained in the smelting works, which is impure, and requires refining for sale.

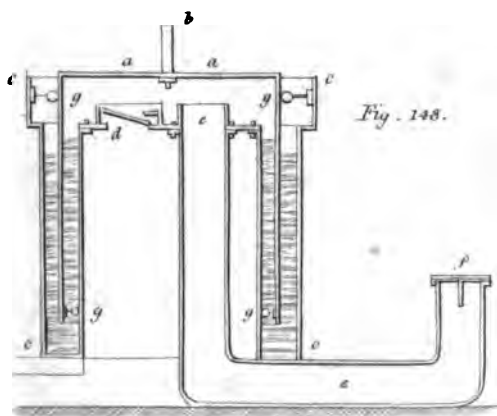
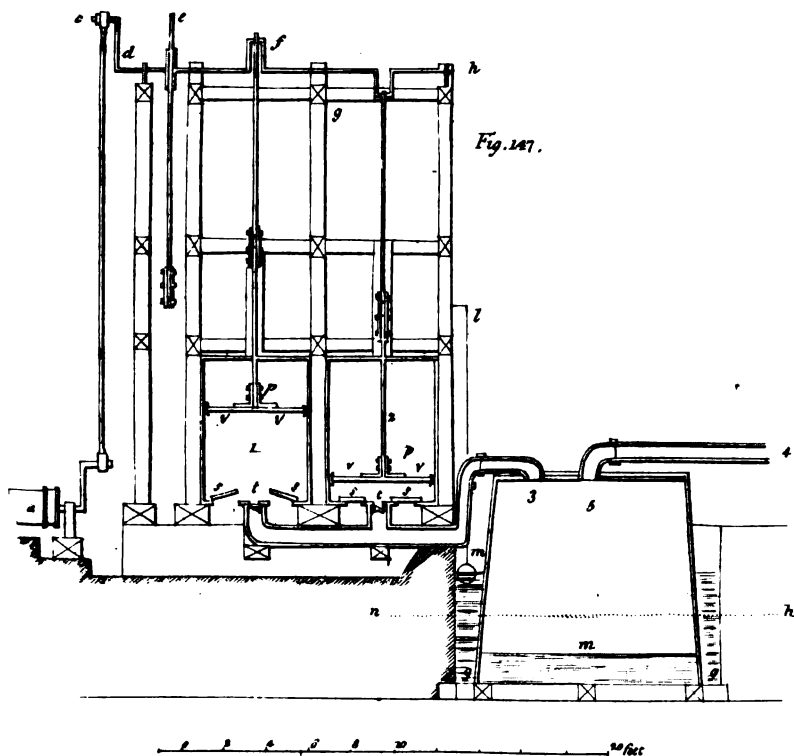
Saleable new lead, is that obtained in the smelting houses, and which does not contain a sufficient quantity of silver to render it profitable to extract that metal.

Workable lead contains sufficient silver to pay for its extraction.

Refined lead, is that reduced from the purest litharge, obtained in extracting silver; the litharge that contains much copper being rejected.

Old lead is obtained by melting old cisterns, lead roofs, and the like; it is rendered impure by the tin of the solder, and melts with a less heat than new lead.

In smelting of lead ores, a considerable difference occurs, some ores being run down for the lead only; which lead, if it contains sufficient silver to pay for the charges of extraction, is afterwards cupelled; the litharge blown off, and the purer





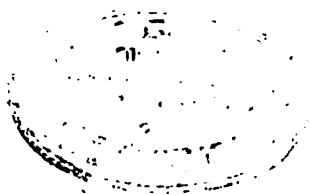


Fig. 149

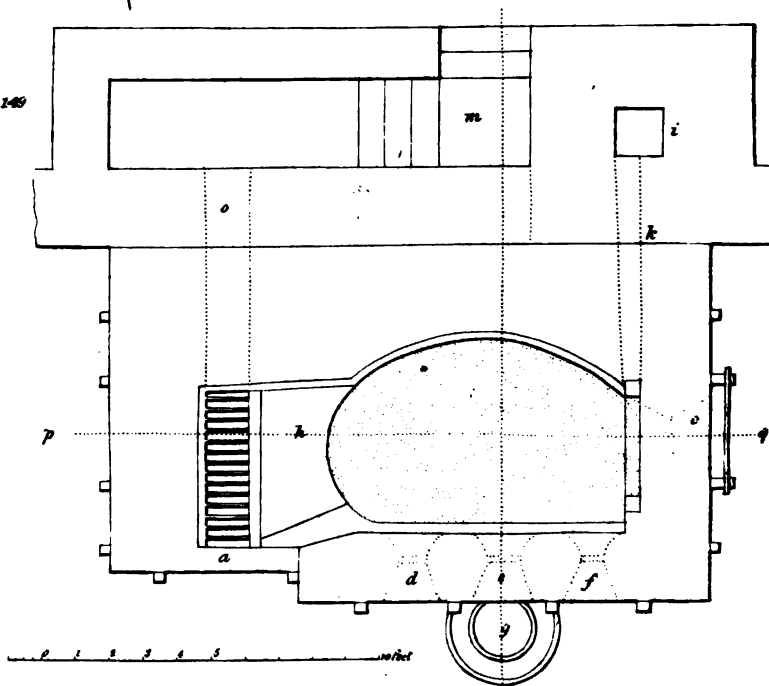


Fig. 150

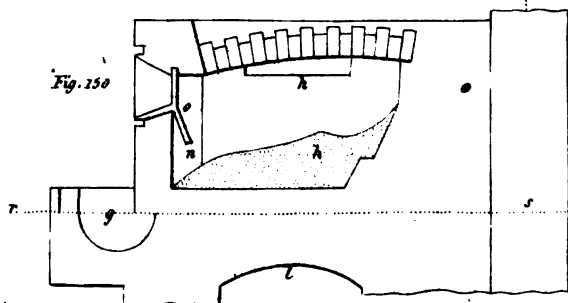
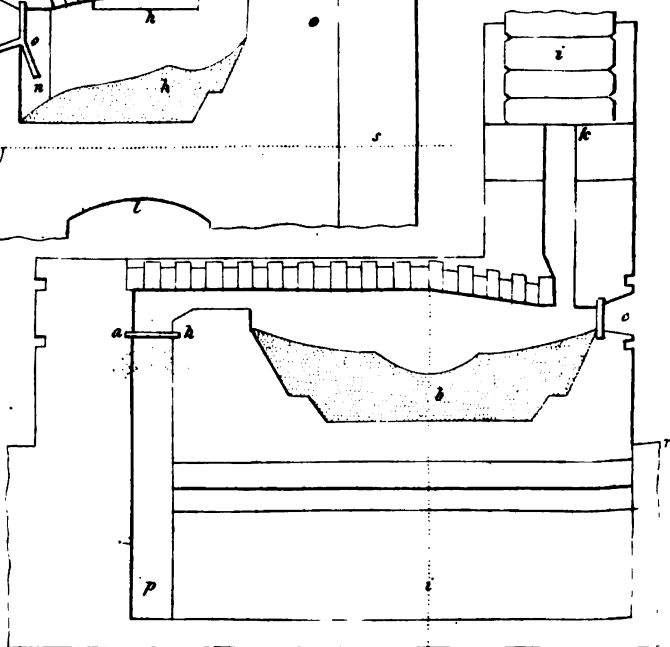


Fig. 151



parts reduced to lead. Other lead ores contain not only silver, but also copper, and these are subjected to a long train of processes to obtain each of these metals separately.

The smelting of the purest lead ores, is best performed in reverberatory furnaces.

Fig 149, represents the plan on the level, *r, s*, in fig. 150, and 151, of the reverberatory furnace used at Poullaouen, in France; which furnace is considered as the best construction hitherto adopted for these purposes. Fig. 150, is the transverse vertical section, in the direction *g, m*, fig. 149, or *b, l*, fig. 151. Fig. 151, is the longitudinal vertical section, in the direction *p, q*, fig. 149.

A, is the fire room of the furnace, with its door and grate. *B*, is the bed, made of clay well beaten together. *C*, is the door by which the furnace is emptied. *D, e, f*, are three doors by which the furnace is charged, and the materials stirred; the middle door, *e*, is also that by which the smelted metal is run out of the furnace, into *g*, the basin prepared for its reception. *H*, is the bridge, over which the flame is directed and carried from the fire room, *a*, to the chimney *i, k*, which is about thirty-five feet high; the first part of the chimney or vent, *k*, lies inclining, and is covered with loose stones only; so that by taking up these stones, the sublimed matter deposited in this sloping channel may be extracted. *L*, is the vault under the bed of the furnace, to breathe out the moisture. *M*, are stairs by which the workmen descend to the ash room, *o*. *N*, is the hole, under the door, *e*, by which the lead runs out into the basin, *g*.

The ores smelted in this furnace are a mixture of the clean ore of Poullaouen, with that of Huel Goet. The Poullaouen ore contains 64 pounds of lead, and three quarters of an ounce of silver, in a cwt. of five score pounds; that of Huel Goet contains 59 pounds of lead, and two ounces and a quarter of silver; the mixed ore contains 61 pounds .89 of lead, in a cwt.

Twenty-six cwt. of the mixed ore is spread on the bed of the furnace, and roasted for six hours by a fire of fagots and billets; the fire is then increased, charcoal is thrown upon the ore through the doors, *d*, and *f*, and the head smelter stationed opposite, *e*, throws in quicklime, which is changed into sulphate of lime, and prevents the liquid metal from running out, until at the end of about an hour and a half; he pierces a hole, *n*, and the metal runs into the basin, *g*, where saw-dust and rosin are thrown on it to reduce any unmetalized particles that may have run out with it; the piercing of the wall of sulphate of lime is repeated every hour, so that eight or nine tappings take place in every smelting. The run metal is laded out of the basin, *g*, into moulds. When the operation is over, the slags are taken out of the furnace by the end door, *e*, and the bed repaired for a fresh charge.

The raw lead thus obtained, is cupelled in a cupola furnace.

The pure litharge obtained in this cupellation is smelted, 76 cwt. at a time, in a similar furnace, being kept in by a wall of quicklime, and is reduced by charcoal flung upon it; this produces sale lead, and some slags, which are reserved and smelted upon a bed of charcoal dust.

The slags, and broken up bed of the first smelting of the

ore, the litharge containing silver, the cupel scum, the broken up bed of the cupel, and the lead smoke taken out of the chimney, are all mixed together and smelted in a low blast furnace; this fusion produces a raw lead, often so impure that it must be smelted again on a bed of charcoal, and scummed, before it is saleable; also slags, the cwt. of which contains about eight pounds of lead, a richer slag from the bottom of the upper basin, and a black slag; all of which are mixed with the other slags, and reduced in the blast furnace.

In all these operations, 100 cwt. of lead for sale requires the consumption of 2275 cubic feet of billet wood, mostly beech, with some oak; 2435 cubic feet of brush wood and broom fagots; and 39 cwt. of oak and beech charcoal.

Fig. 152, represents a vertical section of the blast furnace used at Freyberg, in Saxony, for smelting a lead ore, containing copper and silver; and fig. 153, is the plan, at the level of *n, z*, in fig. 152.

A, b, is the level of the laboratory; *c, d, e*, gutters for carrying off the moisture disposed crosswise, and open to the air at *e*. *F*, is a bed of slags laid upon the flags of gneiss that cover the gutters, *c, d, e*. *G, h*, and *i*, beds of well rammed clay, upon which is laid a bed of clay mixed with ground charcoal, *k, l, t*, forming the hearth of the furnace. *K, l*, is a hollow formed in this hearth, terminating in the receiving basin, *k*. *M*, is the fire-room of the furnace, about eight feet high, open at the top. *N, z*, twyer or blast hole; by which, at Freyberg, the blast from two bellows is thrown into the furnace. *O*, are steps by which the labourers mount to charge the furnace. *P*, is the mouth of the furnace, covered with an arch, *y*, on one side. *Q*, is the front wall of the furnace, under which the melted substances flow from *l*, to *k*. *R, u*, an arch, supporting the steps, *o*, under which an inclined plane, *s*, is made, by which the slags run off from the basin, *k*. *X*, is the lower basin, into which the lead runs when the upper basin, *k*, is pierced.

The following suite of operations are carried on for smelting the lead ore at Freyberg.

1. The working of the lead matt, or first fusion of a washed very poor silver ore, to which is sometimes added some iron pyrites, if a sufficient portion does not accompany the ore. This matt is afterwards roasted. The ore holds only 1 loth (half ounce,) 6 of silver, in a cwt. of 110 pounds.

2. The working of the lead, or smelting of a lead ore, yielding 28 or 30 pounds of lead, 6 ounces of silver, and a very little copper, from a cwt. of the ore. The ore is previously washed, and roasted in a reverberatory furnace, and smelted along with the roasted matt of No. 1, scum from the cupel and other products of cupellation, and any raw lead that is poor in silver. The products of this principal smelting are lead for the cupel, and a matt which is roasted.

3. The smelting of the roasted lead matt, with other lead holding products. The products are a still richer lead for the cupel, and a copper matt, which is sometimes smelted again before it is roasted.

4. Smelting of the copper matt of No. 3, to obtain black copper containing silver, which is afterwards refined.

All the above operations are performed in the furnace just described; but the lead is cupelled in a cupola furnace, and the litharge run down, in a blast furnace.

This running down of litharge into refined or saleable lead, is a very simple operation; fig. 154, represents a longitudinal vertical section of the furnace,

Fig. 151

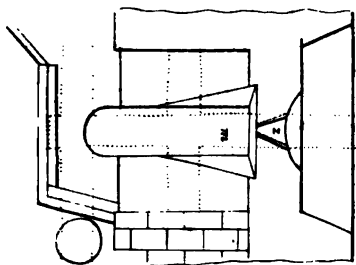
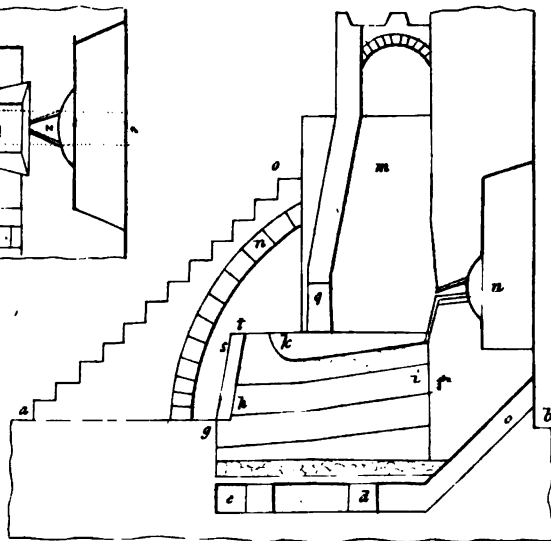


Fig. 152



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 feet

Fig. 154

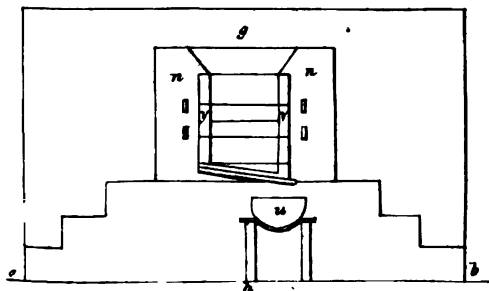


Fig. 155

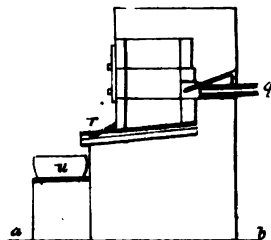
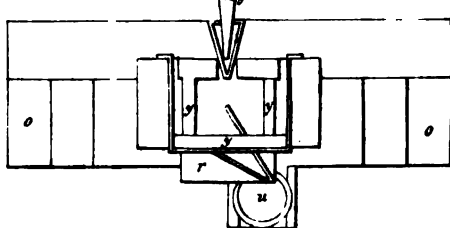
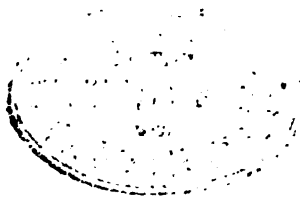


Fig. 156







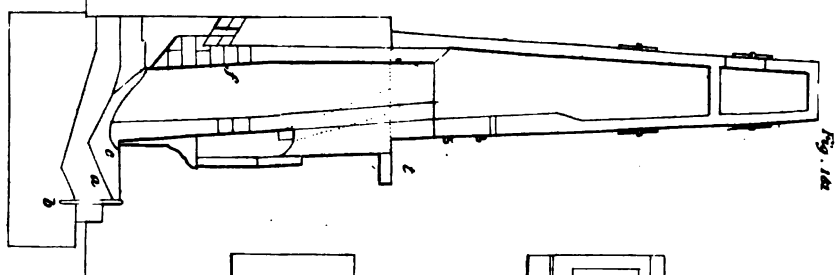
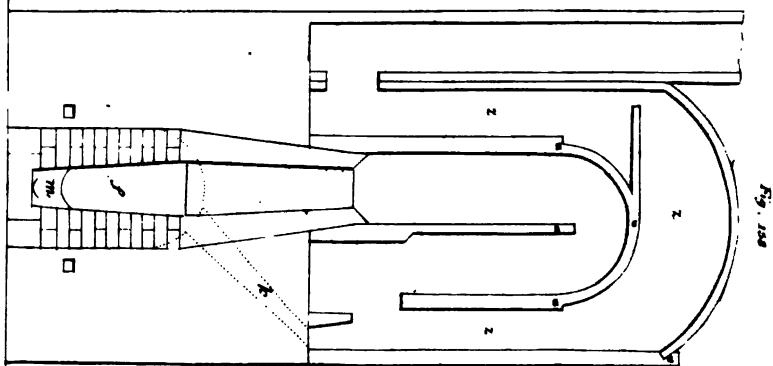
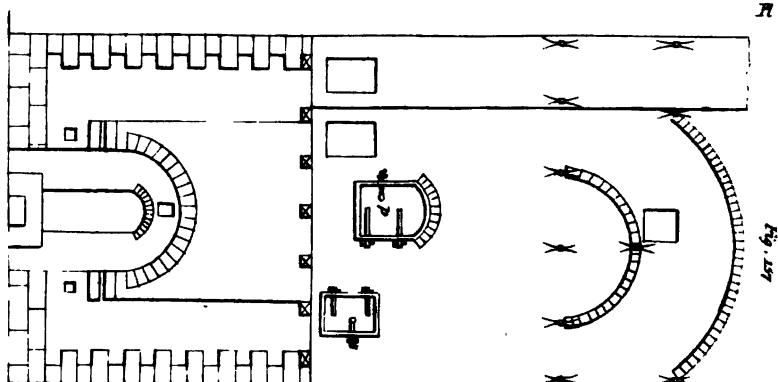


Fig. 159

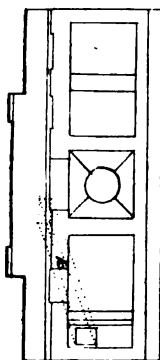
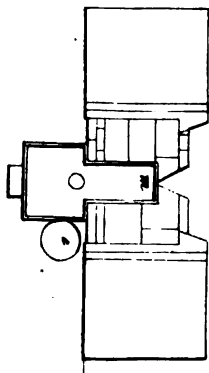


Fig. 160



usually employed for this purpose, on the line, *o, v*, in the plan, fig. 155, taken on the level of the twyer, and fig. 156, is a transverse vertical section on the line, *g, h*, in fig. 154, and *q, r*, in fig. 155. This furnace has also been used for smelting lead ore, and more advantageously than higher furnaces.

A, b, the level of the laboratory. *N*, the walls of the furnace, about two feet high, bound with iron bars worked in them. *Y*, slabs of cast-iron, forming the lining of three sides of the furnace. *Q*, is the twyer, by which the blast is admitted. *R*, a slab of cast-iron, placed on a slope, forming the bottom of the furnace; this slab has two grooves to favour and direct the running off of the metal. *O, v*, are the steps for the workmen to charge the furnace. *U*, a basin of cast-iron, placed on a stove, or in a pot furnace, to receive the metal as it runs from the furnace.

In some countries, much higher furnaces are employed for smelting lead ores, and instead of being open at top, they are enclosed, and furnished with a chimney or chambers; by which means the volatile substances are either preserved for sale, or prevented in some measure from affecting the neighbourhood.

Fig. 157, represents the elevations of a blast furnace of this kind, with a fire-room eighteen feet high, used at the principal lead mines of the Hartz.

Fig. 158, is a vertical section of the same, parallel to the front; fig. 159, a horizontal section on a level with the twyer; fig. 160, a horizontal section on a level with the mouth of the furnace; and fig. 161, a vertical section from front to back.

In all these figures, *a, b*, is the bottom bed of the furnace, with a double lining; the upper lining, *a*, being composed of two parts of clay, and one of ground charcoal; the lower, *b*, of one part of clay, and two of charcoal. *C*, is the upper receiving basin, hollowed out in the lining, as is also the channel, *d*, which leads to the basin. *E*, is the lower receiving basin. *G*, are channels to breathe out the moisture. *K*, is a channel, by which the vapours of the lead in the lower part of the fire-room, *c, f*, can escape into the subliming rooms, *z*, at the top of the furnace. *M*, is a blast hole, by which the wind from two bellows is let into the furnace. *P*, a door, level with the throat, or mouth of the furnace, by which it is charged; the side doors open into the subliming rooms, and are only opened occasionally. *T*, in fig. 161, is the upper floor of the laboratory, on which the charge for the furnace is laid out in distinct heaps. *Z*, are subliming rooms connected below with the throat of the furnace, and the side channel, *k*; and opening into the chimney, which rises upwards of sixty feet from the ground.

Trials have been made in building these furnaces with three, and even seven twyer or blast holes; but this increase of blast has not been found advantageous. A real improvement has been made in placing the charging door, *p*, at the back of the furnace, as the workmen are less exposed to the lead smoke issuing from it when opened; and another in making an opening, *q*, in the front of the furnace, sloping upwards, by which the superintendent is enabled to see whether any flame appears during the operation, which ought not to happen.

The washed ore is first smelted with granulated cast-iron in this furnace, by which there are obtained lead for cupelling, and a matt principally composed of sulphur and iron. The matt is taken off as it cools in rounds, and those of the lower basin, which contain also lead united with silver and copper, are slowly roasted in heaps, of about 2000 cwt. each.

The roasted matt is again smelted along with fresh stamped ore, not containing 30 parts of lead in 100, granulated cast-iron, and any slag which it is supposed will yield some profit. This roasting and smelting of the matt obtained in this operation, is repeated four times in all.

The matt thus obtained is again smelted along with the slags of the first operation, in a low blast furnace, by which it is reduced to black copper cakes. The cakes of this black copper are then smelted in a low blast furnace, along

with twice their weight of lead, or an equivalent of litharge, and run into large round cakes, which are heated in a reverberatory furnace, to sweat out the lead, which carries with it the silver contained in the black copper. The sweated cakes of copper are then exposed to greater heat in another furnace, and thus more lead, holding silver, is sweated out, and the copper is prepared for refining.

The lead obtained from all the preceding operations is then cupelled for silver, and the litharge is reduced to saleable lead.

The lead ores extracted near Goslar, in the Hartz, contains calamine mixed with it, and as this is not separated in the washing of the stamped ore, it goes with it into the furnace, and the spelter or zinc is volatilized: hence a peculiar construction of the low blast furnace used in smelting the ore is adopted.

Fig. 162, represents a section of the furnace used at Ocker Hutte, on the line, * *, in the plan; fig. 163, the plan, on a level with the blast hole; and fig. 164, the front view of the furnace. These furnaces are usually built in pairs, that the produce from each being compared together, this comparison may serve as a check upon the workmen.

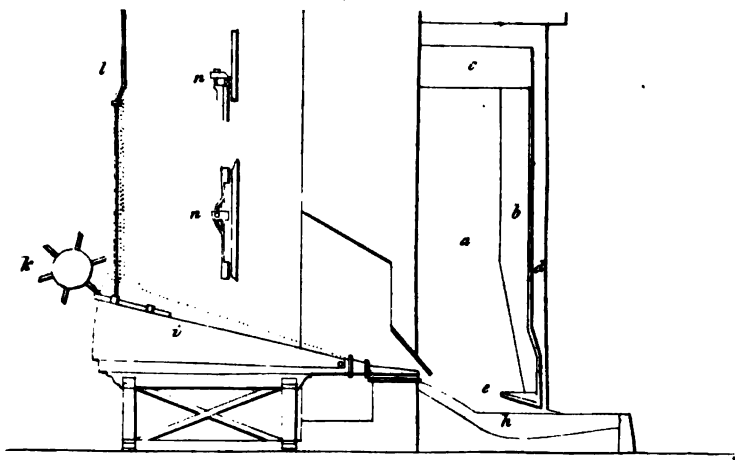
A, is the hinder part of the fire-room, which is charged with the ore and large pieces of charcoal. *B*, is the front part of the fire-room, charged with small pieces of charcoal. *C*, is the mouth of the furnace, by which it is charged, there being a scaffold in front with steps, by which the workmen may ascend; the fire-room being about ten feet in height. *D*, the front wall of the fire-room, which is made of thin slates joined by clay to be the cooler, and thus allow the spelter and oxide of zinc to settle upon it. *E*, is a slab of slate placed at the foot of the front wall, to catch the spelter as it drops from the front wall, and conduct it by the groove, *f*, into the side basin, *g*. *H*, is the bottom bed of the furnace, which is made of one part of clay, and two of ground charcoal.

The blast of this furnace is given by two wooden bellows, *i*, which are pressed down by wipers, *k*, on the arbor of a water wheel, and the upper part raised by the action of a rod, *l*, connected with a counterpoise of stones. The left hand bellows *i*, 2, in fig. 163, is represented open, to show the valves, *m*. *N*, shows the manner in which the leathers, fastened to the side of the upper or moveable box, are pressed against the sides of the lower or immoveable box, to prevent the wind of the bellows escaping that way.

The ore smelted in this furnace is sorted in the mine itself into two sorts: lead ore, and copper ore. 100 parts of the lead ore contain only about three of lead, and never more than nine; and the cwt. of this lead does not yield more than a quarter of an ounce of silver: the copper ore is equally poor.

30 cwt. of the lead ore previously roasted three times over, is smelted in 20 or 22 hours, with 10 or 12 cwt. of the slags of the lead mines of Altenau, collected out of the bed of the river Ocker, 3 cwt. of the old slags of the Lower Hartz mines, and 2 cwt. of impure litharge, and refuse of the refining furnaces. During this operation, which produces about 4 cwt. of lead, and a quantity of slags, part of the zinc contained in the ore is reduced to the metallic state, and attaches itself to the front slates of the furnace, from whence it drops down to the groove that conveys it out of the furnace into the side-re-

Fig 16a



9 Fig. 123.

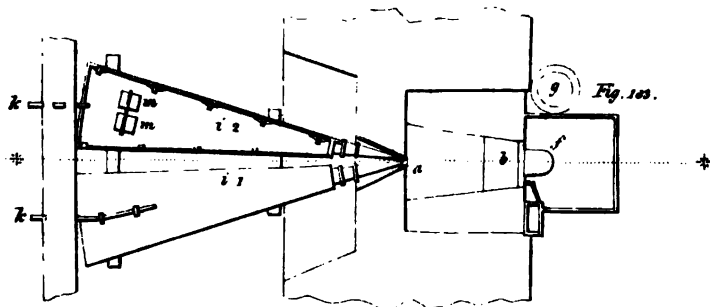
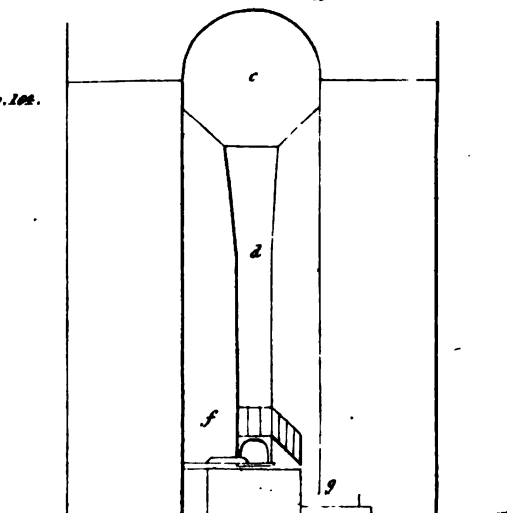


Fig. 10x.





ceiving basin. The greatest part of the zinc, however, is burned as fast as it is reduced, and about 2 cwt. of the oxide fixes on the walls of the furnace in each round of thirteen smeltings, that take place every twelve days. These flowers of zinc are used for making brass. The quantity of metallic zinc obtained is very small, and very variable; it never exceeds eight pounds in each smelting.

The lead ores of some countries, as at Wedrin, near Namur, Bleyberg in Carinthia, and Bleyberg near Aix la Chapelle, not being mixed with copper ores, are smelted in a far simpler manner, being only washed and then put into a low blast furnace.

At Wedrin, the ore is mixed with brown oxide of iron, and iron pyrites; the latter only is roasted. 310 cwt. of ore, to which, if poor in iron, the scoria of iron is added, yield, in 160 hours, 100 cwt. of lead; and 106 cwt. of charcoal are consumed. At Bleyberg near Aix la Chapelle, 30 cwt. of washed ore, made into bricks with $2\frac{1}{2}$ cwt. of slaked lime, are smelted with 12 cwt. of the slag of iron fineries; the fusion takes up 24 hours, consumes 8 cwt. of coke, and one of charcoal, and yields about $7\frac{1}{2}$ cwt. of lead.

The lead ore of Northumberland is roasted in a reverberatory furnace, and during this operation a white sublimate collects in the chimney, composed of carbonate of lead and oxide of antimony, which is collected and sold for painting by the name of *lead smoke*. The roasted ore is smelted on a low blast furnace, like fig. 154, along with quicklime: the fuel used is raw coal.

The Chinese reduce lead very expeditiously into very thin sheets. A man sits on a floor with a large stone slab before him, and a moveable flat stone on its edge. His fellow workman, who stands by his side, pours a small quantity of melted lead on the slab, and the first workman instantly dashes down the moveable stone on the melted lead, which presses it out into a flat and thin plate, which he immediately removes from the slab. The rough edges of these plates are then cut off, and they are soldered together for use.

Plumbers' Solder,

Is made by melting together twenty pounds of lead, with ten of tin; in a gentle heat, and pouring it out into moulds made in sand. It is used to join sheets, or pipes of lead together.

Printers' Type Metal.

The basis of type metal is lead, to which the letter-founders add one-fourth its weight of regulus of antimony, and sometimes tin, copper, and zinc, in various proportions; but a good alloy for this purpose is yet wanting. It might probably be improved by uniting the metallic ingredients in the ratio of their atomic weights.

Lead Shot.

Slag, or poisoned lead, is first prepared by melting 20 cwt. of soft pig lead in an iron pot, then strewing a peck of coal ashes or dirt round the edges, to defend the iron from the arsenic, 40lb. of which, either white or yellow, are

then put in, the pot covered, the cover luted with clay, the pot kept red hot for three hours, then uncovered, the poisoned lead skimmed and ladled out into sand moulds.

20 cwt. of soft pig lead are then melted, and the poisoned lead added; trials are made by dropping some of the lead into water from the height of two feet; if the shot be not round, more poisoned lead is to be added. When the proper quantity is added, the metal is ladled out into a cullender, and let to drop into water; the cullender being from 10 to 150 feet or more, above the surface of the water, according to the intended size of the shot.

Litharge.

This is always a secondary product, in the processes for obtaining silver.

Litharge, is the *acidum plumbicum* of Berzelius, or P b., equal to 2,789,000; and the *protoxide of lead* of Dr. Thomson, or P b., equal to 14,000.

Litharge is united with oil, either in a small proportion to make it dry sooner, or in a large proportion, to form a cement for cisterns, or plasters for surgical purposes. It is also used in the composition of glass, as a flux.

Red Lead.

In Germany, 180 pounds of lead are calcined for eight hours upon the hearth of a cupola furnace, and being constantly stirred, it is then left in the furnace for sixteen hours, and only stirred at intervals.

This calcined lead, or massicot, is ground small in a mill with water, washed on tables, and being dried is put into stone pots, of such a size, that 32 pounds fill them somewhat more than a quarter full. Several of these pots are laid horizontally in the colour furnace, so that the flame may go quite round them, and a piece of brick is put before the opening of each pot. A fire is kept up in this furnace for about 48 hours, and the matter in the pots stirred every half hour. The red lead being finished, is then passed through a sieve. In this operation, 100 pounds of lead generally increase 10 pounds in weight.

In England, red lead is made from litharge, which is put into pots, and these being placed in a reverberatory furnace, a gentle fire is kept up for a couple of days, and the litharge frequently stirred.

Red lead is mostly used as a colour. It is the *superoxidum plumbosum* of Berzelius, P b.; and its weight 2,889,000; and the *deutoxide of lead* of Dr. Thomson, 2 P b O², and its weight 14,500.

White Lead.

White lead is made by rolling up six pounds and a half of thin cast sheet lead into rolls, so as to leave a small space between each roll. A number of earthenware pots being then half filled with vinegar, the rolls of lead are lightly jammed into the mouth of these pots, so as to be supported above the vinegar. About 560 of these pots are placed in a layer of

spent tanners' bark, confined in a wood frame, and boards being placed over them, and supported by a frame of boards placed endways, a fresh layer of spent tanners' bark is put on the boards, and on this a fresh bed of pots, and so on, until seven beds of pots are made into a stack.

These stacks are then left until the vinegar is completely evaporated, which takes up about three months, when they are pulled down, and the corroded lead is separated from the pot, but as the lead usually sticks so tight in the pot that the labourer is obliged to knock the pot against the box, the dust afflicts the workmen with the Devonshire, or Painters' Colic, and there is much breakage, generally 30 pots in each bed of 560.

In some works each bed consists of only 280 small pots, filled entirely with vinegar, and over these is placed a flooring of boards pierced with gimlet holes, to allow the vapour of the vinegar to pass. Rolls of lead, to the extent of three tons in weight, are placed on this pierced flooring, which is supported by strong boards, placed edgeways round it; and are in like manner covered by another flooring, supported also by boards. By setting the stacks in this manner, the manufacturer obtains $\frac{1}{3}$ more white lead; there is no breakage of the pots, nor, the rolls being well sprinkled with a watering pot with a rose, is there any dust.

A part of the white lead thus obtained is left in the flaky form, by merely unrolling the plates, and is used in fine painting by the name of *flake white*. Another portion is ground with water, made into small lumps, and sold by the name of *ceruse*. But the greater part is ground in water, with certain proportions of chalk, and sold in large lumps by the name of *white lead*.

The sheets of blue lead must be cast rough, for rolled sheet lead is but slightly attacked by the vapour of vinegar.

The principal use of white lead is for paint, not only as a white colour, but also to serve as a body with which other colours, even the darkest, are mixed, on account of its opaqueness.

White lead is the *carbonas plumbicus* of the Northern chemists, P b: C: 2 and its weight is 3,339,333; according to Dr. Thomson, and the Southern chemists, who call it *carbonate of lead*, P b: C: its weight is only 16,750. It is the *plumbi subcarbonas* of the present medical faculty.

The German white lead is manufactured from the lead of Bleyberg, in Corinthia, on account of its purity.

The lead is cast by being poured upon a sheet iron plate, and as soon as it begins to fix, the plate is sloped, and thus a sheet of lead is left on it one-forty-eighth, or one-twenty-fourth of an inch in thickness. By cooling the plate with water, several cwt. of blue lead are cast into sheets in a day.

Instead of pots, boxes five feet long, one foot broad, and about ten inches deep, are used. The lower part of the boxes is pitched about an inch high; the upper part has sticks placed across. The acid mixture poured into each box is in some manufactories made of a gallon each, vinegar and wine lees; in others of 20 pints of wine lees; $8\frac{1}{2}$ pints of vinegar, and 1 pound of pearl-ash. The vinegar is usually made of crab apples and water.

The leaves of blue lead being trimmed to a proper size, are doubled and hung over the sticks in the upper part of the box, so as not to touch one another, nor the sides of the box, nor the acid liquor. A cover is then put on; and if a dung heat is used, or the mixture contains pearl-ash, the joints are carefully closed with paper pasted over them. The more usual mode is to dispose the boxes in a large room heated by stoves to about 86 deg. Fahr.; a greater heat would evaporate the acid too fast.

In about a fortnight the corrosion is finished, and the sheets of white lead are found near $\frac{1}{4}$ inch thick, and covered in some places with crystals of sugar of lead. As much as can be got off by a moderate degree of force, is very carefully washed. This washing is esteemed the most delicate part of the whole manufactory; during the progress of it, a white scum appears which is taken off, and a little pearl-ash being added to it, it is changed into white lead, of a beautiful whiteness, and is sold for choice purposes: the remainder is mixed with a pure sulphate of barytes, brought from the Tyrol, in different proportions, according to the market for which it is designed.

In France a solution of lead is first prepared by adding at least 174 pounds of finely ground litharge to 65 pounds of pyroligneous acid; of such strength that 22 grains and a half of this acid may saturate 25 grains of well crystallized subcarbonate of soda; 15 to 20 times as much water is usually added. The whole is left for a short time, and the clear being poured off, some fresh acid and water is poured on the sediment, to take up any oxide that might have escaped the action of the first parcel.

The clear solution decanted off the residuum is run into large, but shallow, covered cisterns, and carbonic acid gas is passed into these cisterns by a large number of pipes. This carbonic acid gas is procured by the burning of charcoal in a close stove, and passing the burnt air into the liquor. When no more settling appears to be formed, the whole is passed into a deep cistern, and left there for some hours, when the liquid part is poured off in order to be combined again with more litharge, some fresh acid being also added.

Part of the sediment left in the cistern is well washed, and produces a dull milk-white lead with several portions of fresh water. Generally the washing is not continued to such exactness, because buyers prefer white lead that has a slight bluish tinge; now the copper contained in the litharge produces the colour, provided the settling is not washed too much. A gray tinge is sometimes preferred; which is produced by adding a small quantity of common ivory black, which must, however, be well mixed with the white lead.

The white lead is then moulded by putting the well-drained mass into glazed pots of the proper shape to imitate that of the Dutch white lead leaves. These pots are then stoved, and the white lead packed in pale blue paper, the reflection of which gives it a more agreeable cast of colour.

[This method of manufacturing white lead by precipitating the acetate or pyrolignite, of lead, by carbonic acid, has been tried on the most extensive scale in this country, with great loss and a total failure in the enterprise. A beautiful pigment is indeed produced to all appearance, when viewed in the mass; but, owing to some unexplained circumstances, it lacks the peculiar density and opacity of the article prepared in the old method, by the corrosion of the metallic lead with the fumes of vinegar. It wants those properties which are implied in the painters' term, *body*.

The manufacture of white lead is carried on extensively in this country by several manufacturers, who obtain their acetic acid by the fermentation of potatoes and subsequent distillation.]

Sugar of Lead, or Saccharum.

This salt is an object of considerable interest, on account of the great use made of it in some arts, as in painting. In the calico printing business it is in reality one of the most usual preparatives, or according to the French term, *mordant*, or biter in.

In the process formerly used, cast lead was cut in pieces by chisels; these cuttings were put into pans, and a small quantity of vinegar was poured on them, but not sufficient to cover them. The part which was not sunk beneath the acid becomes oxidized in a short time, and as the cuttings were stirred several times a day, in order to change the surfaces exposed to the air, or to the acid, the oxide was gradually dissolved in the vinegar. When the acid was saturated with the acid, the liquors in the several pots were poured into a tinned copper boiler, and boiled down one-third; the liquor was then filtered, and

boiled down again, until on trial, it appeared fit for crystallizing; it was then decanted and set by to crystallize, the first crop was large and white needle-like crystals; but the mother waters, by farther evaporation, yield coloured crystals.

The colour of these crystals appear to be owing to the oil in the wine vinegar.

The Dutch manufacturers use those distilled vinegars that are exempt from oily particles. Distilled cider vinegar, is found to yield a very pure saccharum, even to the last drop, which is as beautiful as the first; pyroligneous acid, carefully freed from the tar, is now used in England and France.

As 100 parts of saccharum are composed of 58 of oxide of lead, 26 of dry acetic acid, and 16 of water; of course, the saturating power of the pyroligneous acid must be examined. When this acid is at eight degrees of Baumé's hydrometer, it generally requires 68 pounds of it to be poured on 58 pounds of litharge. The solution takes place immediately, and is so quickly made that a considerable heat is produced, which retains the sugar of lead in solution; but a little fire is usually given, and some water added, to keep up this solution until the liquor has become clear, and it is then poured into crystallizing pans.

The crystals usually weigh 75 pounds; they are drained and carefully dried. The mother water, which contains about 25 pounds of the saccharum, yields, by evaporation, great part of its content, but the crystals are by no means so fine as the former. When the mother water no longer yields crystals, it is mixed with subcarbonate of soda; a carbonate of lead falls down, which is used instead of litharge, in future operations.

It will be found preferable at first to add the mother water to the acid and litharge, and thus nearly 100 pounds of good sugar of lead will be obtained instead of 75 pounds, by the first crystallization; but this method cannot be continued for any time, as the liquor will become greasy, the crystallization will be hindered, and the sugar of lead becomes difficult to drain; so that it is then necessary to abstain from adding the mother water any longer to the solution, and to decompose it by subcarbonate of soda.

To obtain a very white sugar of lead the metal or litharge should have no admixture of copper; the copper, however, gives the sugar of lead a slight bluish tinge which pleases the eye of many of the buyers.

In this solution of the litharge in the acid, there remains a very small residuum, which may be treated as an ore of silver, as it is composed of that metal, united with oxide of copper, of lead, and some earthy substances.

It is a great advantage in this manner of forming sugar of lead, that it is not necessary to evaporate the solution, for the solution is decomposed by being boiled, and part of the sugar of lead is changed into white lead, and of course separates in the form of a powder.

[The following is the method of preparing the pyrolignite, or brown sugar of lead in Lancashire.—Saturate the re-distilled pyroligneous acid in a copper boiler with litharge; allow the oxide of lead not dissolved to subside; then decant the clear liquor into another boiler and evaporate the clear solution of sub-acetate of lead till a drop let fall upon a cold stone crystallizes, or sets hard, which may take place at 1.980; now add to the liquor one half its bulk of the strongest distilled pyroligneous acid, and evaporate again till when poured upon a cold stone minute centres of crystallization form in various parts, and successive circles appear, of which each spot is a centre, forming an appearance similar to knots of mahogany. Lastly, pour the liquor into a shallow copper vessel, when it will concreate into a solid mass.]

Sugar of lead water is used to ascertain the presence of sulphuretted hydrogen, or hydro-sulphuretted alkalies in mineral waters, as also of boracic and carbonic acid.

Sugar of lead is the *acetæ plumbiæ cum aqua* of Berzelius, and the northern chemists, or $P: A = 3 + 6 H^2 O$, and its weight 4,750,800, Dr. T. Thomson, and the southern schools call it *acetate of lead*, or $P: A = 3 H$. equal to 23,625.

Nitric Solution of Lead.

Cuttings of lead, or granulated lead, dissolve easily in weak nitric acid of any kind.

[The solution of metallic lead, even when in a state of minute mechanical division, is far from being effected with the facility, which is desirable in the manufacture of the article on a large scale. The more usual method is to dissolve litharge in single aqua fortis to saturation heated in an earthen vessel in a hot water bath; the saturated hot solution deposits crystals on cooling. A more ingenious method has been devised by Dr. Warwick. He dissolves 30 lbs. of sugar of lead in 10 gallons of water, and then saturates the solution at a boiling heat with litharge, of which it will require a considerable quantity, and form a sub-acetate. To this, when cold, he adds as much triple aqua fortis as will decompose the whole acetate of lead; it may require about 34 lbs. Pour the liquor from the nitrate of lead, which will fall down in minute crystals into an earthen vessel. Saturate again with litharge, and proceed as before. The object of this process is to take advantage of the superior solvent power of the acetic over that of the nitric acid over the oxide of lead. The same acetic acid will serve for any number of times, and both acids are sufficiently concentrated to supersede the necessity of evaporation altogether. For immediate use, the crystals of nitrate of lead may be used in this state; but for sale they should be dissolved in boiling water and recrystallized slowly.]

This salt is now much used in calico printing.]

Wooden sticks, impregnated with nitric solution of lead, are recommended by Pronst to be used to fire artillery, instead of the port fires usually employed.

Turner's Patent Yellow.

This metallic colour may be made by pouring upon litharge one-third of its weight of strong muriatic acid, and after letting it stand, for 24 hours, melting the whitened litharge, by which it becomes yellow.

It is also prepared by rubbing red lead or litharge along with one-fourth its weight of common salt, and a little water, exposing the mass to heat, and then washing out the carbonate of soda from the mineral yellow.

It is used as a paint, but the superior beauty of chromate of lead has diminished its consumption: its use was, however, a great relief to the coach-painters, most of whom formerly fell early victims to the fumes of the orpiment formerly used: as a bright yellow was, and will, probably, ever continue the favourite colour for carriages.

TIN.

THERE are several sorts of this metal in the market.

Cornish block tin, in large blocks of about 300 pounds each, or small blocks of 30 or 35 pounds; this is obtained from tin ore mixed with copper pyrites; it does not contain more than one-five hundredth of other metals; seldom, indeed, more than one-thousandth of copper, which, when the metal is dissolved, separates in the form of a black oxide; represented by the advocates of medical police as arsenic.

Refined block tin, in small ingots of from one pound and a half to two pounds, or in rods of a half pound each.

Grain tin, in blocks of 120 or 130 pounds, but is generally in fragments resembling rocks, which form is given it by letting the blocks fall from a great height while hot. It is obtained from the pure oxide of tin, of the stream works of Cornwall, very brilliant, and the purest English tin: seldom containing more than one-ten thousandth of iron, and is usually 20s. or 30s. by the cwt. dearer than block tin.

German tin, in bricks of about 8 or 10 pounds each; it contains much iron, and is liable to become spotty with rust.

Malacca tin, imported from the East Indies in pyramidal ingots, of different sizes, from a half pound to one pound and a quarter. This is esteemed the purest kind, and used in making organ pipes, and other nice work.

Banca tin, from Siam, in flat blocks of 120 or 130 pounds: also very pure.

German Tin.

This tin is usually found in the form of oxide, and smelted in blast furnaces, which, in different countries, vary in height: the ore being first stamped and washed.

Fig. 165, is the plan, on a level with the blast hole, of the low blast furnaces used with some slight variations in Cornwall and Saxony for smelting tin. Fig. 166, is the vertical section.

Fig. 166.

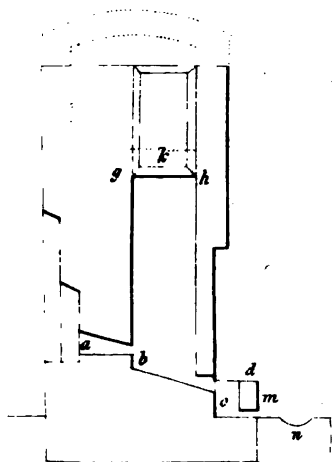


Fig. 165.

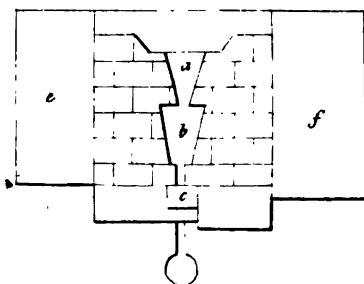
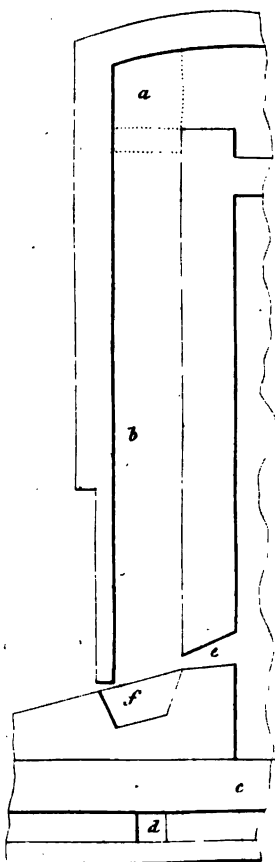


Fig. 167.



For Fig. 165. & 166.

1 2 3 4 5 10 feet

Fig. 168.

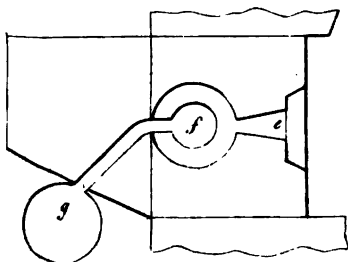
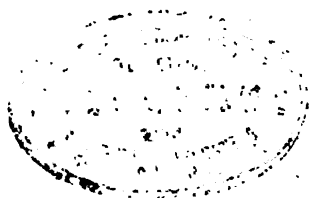


Fig. 167. & 168.

1 2 3 4 5 6 8 feet



A, is the twyer, or blast hole, which admits the blast of a pair of wooden bellows, or that of a blowing cylinder. *B*, the bed of the furnace, made either of clay or a granite slab. *C*, the upper basin, to receive the matters that flow out of the eye of the furnace. *D*, a ridge of stone on which a little small charcoal is kept to sprinkle occasionally on the tin collected in the basin, *c*. *E*, *f*, are two strong side walls, in one of which is the charging door, *k*, opposite to this is another door, opening into a subliming room, as shown in fig. 166, by the dotted lines. The use of this subliming chamber is not adopted in the English furnace. *G*, *h*, and *b*, is the fire-room. *K*, is the opening by which the ore and coal are flung into the fire-room. *L*, *m*, is the floor of the laboratory, on which the tin runs from the upper basin, *c*, into a lower basin, *n*, as often as the eye of the furnace, *m*, is pierced.

This furnace is generally from six to eight feet high, from the bed to the opening by which it is charged.

At Slackenwald, in Bohemia, the tin ore which is mixed with iron pyrites and arsenical pyrites, is first stamped, washed, and roasted, in parcels of 4 cwt. in a reverberatory furnace, for from 3 to 6 hours. The white arsenic is collected in a subliming room, about 300 feet long, forming a horizontal communication between the furnace and its chimney. This subliming room is opened twice a year, and about 50 cwt. of white arsenic extracted each time. Part of the white arsenic is distilled with sulphur in cast-iron retorts, and thus made into red and yellow arsenic.

The roasted ore is washed upon sleeping tables, and the pyrites now rendered lighter, carried off by the water; which also takes away about fourteen pounds of copperas from each 40 cwt. of roasted ore.

10 cwt. of this washed ore, well moistened, is then smelted every 24 hours in a low furnace, with moistened charcoal, to damp the fire. The smelting lasts about 16 hours, and the eye being pierced four times, about 4 cwt. of tin are obtained; 100 cubic feet, or 920 pounds of charcoal, are consumed.

Fig. 167, represents the vertical section of the high furnaces used also at Slackenwald, in Bohemia, for this smelting. Fig. 168, is the plan of the furnace, on the level of the blast hole.

A, is the charging door, just over the fire-room, and at the commencement of the subliming room, which is constructed over the furnace, and is only indicated in the figure. *B*, is the fire-room, which is about fifteen feet high. *C*, the foundation of the furnace, below the floor, with its channel, *d*, for breathing out the moisture. *E*, the blast hole. *F*, the upper basin, lined with clay and charcoal dust mixed. *G*, the lower basin, into which the metal runs when the eye is pierced.

A continual smelting is kept up in these furnaces for a fortnight, during which time 300 cwt. of dressed ore, yields 125 cwt. of tin, and about 210 cwt. of charcoal is consumed. Hence, this furnace consumes only seven-tenths of the charcoal that would be required for the smelting of the same quantity of ore in the low blast furnaces; and there is a still greater saving of

time, as this high furnace furnishes twice the quantity of metal in a day more than the other.

These high blast furnaces, however, although a trial has been made of them in Cornwall, have not been approved there, probably from want of knowing the minute attention which certain parts of the process may require.

Grain Tin.

In Cornwall, the alluvial tin ore, or stream tin, obtained from the stream works, and which is composed of pure oxide of tin, without any admixture of pyrites, arsenic, blende, or copper, is smelted in blowing houses, in low blast furnaces like the German, but open at top; 15 cwt. of clean ore generally yields in twelve hours 10 cwt. of grain tin, and the smelting consumes 280 cubic feet, or about 23 cwt. of charcoal. The bottom of the furnace is a mere slab of granite, and the eye being always open, the metal runs in a channel three feet long, in order to allow the slag to be taken off into a basin; from whence it is ladled into an iron kettle, where it is refined by keeping pieces of charcoal soaked in water, under its surface, then skimmed, and laded into moulds.

The slags are passed four times through the same furnace; and afterwards stamped, to separate any metallic grains.

Mine Block Tin.

The mine tin of Cornwall, or that extracted from the veins in the mines, is stamped, washed, and then roasted in a reverberatory furnace. The roasted ore is then stamped and washed again, until it becomes so clean as to yield by assay, one-half or three-fourths its weight of tin. It is then sold to the smelting houses.

The roasted ore is mixed with a little coal, or Welch culm, and some slaked lime, the whole well moistened, and smelted in a reverberatory furnace, which is seven feet long, five broad, and about fifteen inches deep, 7 cwt. of the ore are smelted at once, and yield about two-thirds its weight of tin.

To obtain 100 pounds of tin, there is consumed, in the roastings, 38 pounds of coal, and in the smelting, 170 pounds; in all, 208 pounds of coal.

The tin that remains in the slag, is separated by stamping and washing, and is called *prillion*; it is then melted into a mass.

Refined Block Tin.

This block, or common tin, is refined by melting it by a gentle heat, on the bed of a reverberatory furnace, and allowing

it to run as it melts, into an iron kettle, with a small fire under it: the least fusible substances that may be present, are left on the bed. The tin in the kettle is farther refined, by taking it up in a ladle, and pouring it repeatedly into the kettle again, skimming it, and finally keeping it melted for some time, and lading out only the upper part.

Silvering and Gilding by Powdered Tin.

A quantity of pure tin is melted and poured into a box, which is then violently shaken; the metal assumes when cold the form of a very fine gray powder. This is then sifted to separate any coarse particles, and is mixed with melted glue.

When it is to be applied it should be reduced by the addition of water to the consistence of thin cream, and is laid on with a soft brush, like ordinary paint. It appears when dry like a coat of common gray water colour, until it is gone over with an agate burnisher, then it exhibits a bright uniform surface of polished tin. If the glue is too strong, the burnisher has no effect; and if too weak, the tin crumbles off under the agate. A coating of white or gold coloured oil varnish or lacquer, is immediately laid over it, according as it may be intended to imitate silvering or gilding.

It is used for covering wood, leather, iron, or other articles in constant wear, as it is very ornamental, and resists the effects of the weather.

Pewter.

There are three kinds of pewter.

1. *Plate Pewter*, used for dishes and plates; this is the best kind, and contains the smallest quantity of other metals added to the tin, which forms the basis of all sorts of pewter. Seventeen pounds of regulus of antimony, added to 100 of tin, form a good plate pewter; some add a small quantity of copper, zinc, or bismuth. A very fine silver-looking metal is made from 100 pounds of tin, melted with 8 of regulus, 4 of copper, and 1 of bismuth.

2. *Trifle pewter* is used for making the pots for drinking beer; its quality is inferior to the plate pewter.

3. *Ley pewter* is used for wine measures, and large vessels; from its specific gravity it must contain more than one-fifth of lead.

The use of pewter vessels has been represented by the advocates of medical police, and persons interested in the pottery business, as unwholesome. The following experiments show the error of this opinion. Nine vessels of different qualities of pewter were cast, and filled with boiling vinegar, and kept for three days. The vinegar of the eight first vessels when assayed by means of

the sulphate of potash, did not present the slightest portion of dissolved lead; the ninth was charged with the latter metal. Hydro-sulphuretted water discovered the tin which was dissolved in the eight first liquids.

These experiments were repeated three times with vinegar of different strength, and the same results were obtained. The tin, which is always more soluble and more easy to be oxidated than the lead, easily suffers itself to be attacked by the vinegar, but the lead not at all. The vessels, after the vinegar has been kept in them, appear, indeed, of a leaden colour, and to abound more with lead than the piece does in its substance; but the slightest friction detaches the light stratum which is formed at the surface, and restores the vessel to its original state.

It is well known that the poorest pewter, such as that of 20 per cent. is never employed in the fabrication of the utensils which serve for preparing and preserving our aliments and drinks. But even though a dishonest pewterer should employ it, his alloy can never be injurious to health, since vinegar may be kept in vessels alloyed with 33 or 50 per cent. of lead, without its being possible to detect a sensible quantity of this metal in it. And as to the arsenic which Malouin, Geoffroy, and Margraaf had detected in some tin, the supposed danger thence arising, was soon dissipated by the work which Bayen wrote upon this subject by order of the police of Paris, and in which he observes that a pewter plate which he had employed for two years at all his meals, had lost only four grains of its weight, and that the arsenic which could be contained in these four grains, detached by scouring the plate, rather than introduced into the stomach, did not amount probably to one five thousand seven hundred and eightieth of a grain per day.

Biddery Ware.

Biddery ware is of a black colour, and as it never fades, and when tarnished may be easily made to look as if new, might be used more advantageously for the formation of ink stands, and some similar articles, than the brown bronze now in use for the finer articles of that description.

Biddery ware is made by adding 24 pounds of tin to one pound of copper in a melted state. The mixed metal is of course in this stage of a white colour, and is made into the required form by the usual method used in casting small articles. The article being cast, and, if necessary, dressed, it is then scraped with a knife, and coloured of a lasting black colour. Equal parts of sal ammoniac in powder, and of the reddish saltpetre earth found in the neighbourhood of Biddery, are made into a paste with a little water, and rubbed on the metal, which instantaneously assumes a lasting black colour. Sometimes, indeed, this ware gets a little tarnished, and acquires a brownish colour, but the fine sable hue is immediately restored, on the article being merely rubbed with a little oil or butter.

In some other places of India they melt together 16 ounces of copper, 4 of lead, and 2 of tin, and having poured out this metal into ingots, they then melt 3 ounces of this mixed metal along with 16 of spelter, and cast their articles in the usual way.

As the saltpetre earth contains not only saltpetre but also common salt, so in places where it cannot be procured, the articles are washed with a solution of 1 ounce of sal ammoniac, a quarter ounce of saltpetre, another quarter ounce of common salt, and the fifth part of an ounce of blue vitriol, which last might probably be omitted.

[*Muriate of Tin.*]

Take the best grain tin; reduce it to a state of minute division by pouring it while melted, and near a red heat by day light, from a height into a large vessel of cold water; fill with this feathered tin, as it is called, the third, fourth, fifth, and sixth receivers when distilling muriatic acid, as already described, and then add to each receiver six gallons of water. The salt is formed in the process of distillation. When the solution is cold, pour it into a copper boiler, which should be filled, at least, one-fourth full of feathered tin to prevent the action of the muriatic acid on the copper. The tin must be replenished as it dissolves away. Evaporate the solution to 1.960; let it stand an hour or two, and pour the clear liquor into shallow earthen vessels of about two gallons each. The crystals of muriate of tin will form in the course of a few hours. Pour the mother water back into the boiler, and drain the crystals. Evaporate and repeat the process.

Oxymuriate of Tin.

This is the permuriate of tin of the more modern nomenclature, which, with the foregoing, are salts of great importance in the arts of dyeing and calico printing. The usual method of preparing the oxymuriate of tin, is this:—Take four parts of double aqua fortis, at 1.320 or 64° of Tweedale's hydrometer, and one part of the very best and strongest muriatic acid; it should have a specific gravity of 34° T. Mix the acids, and add grain tin in lumps of half pound each successively as they dissolve, until the liquor acquires a specific gravity of 1.600 or 120° T.

Dr. Warwick's method is, to take the strongest solution of muriate of tin, (say at 140° T., as obtained from the receivers in the process of making the muriate of tin,) and mix it with double aqua fortis, in the proportion of one measure of the former to two of the latter; then add tin by degrees till the solution acquires a specific gravity of 120° T. or 1.600, water being one.

Another and more recent method practised by the same intelligent chemist, and to which he gives the preference, is this:—Take one pound of the finest and most silky crystals of tin,

and pour upon them eight ounces of double aqua fortis, and mix well together. If the action does not commence immediately, apply the heat of a candle or burning paper to the outside of the vessel, when a violent effervescence will take place: as soon as the fumes will allow the operator to approach the vessel, stir the mixture till the action is over. The violence of the action of the materials in this process approaches almost to an explosion, and the operation requires considerable caution in the management of it.

In the first of the three foregoing processes the tin is wholly oxidized at the expense of the nitric acid. In both of the last the protoxide of tin is formed at the expense of the water, as the muriatic acid affords no oxygen. The second process is rather the cheapest. The last is the most expensive on account of the muriate of tin being required in the crystalline form. The product of the last process contains less excess of acid, which is unnecessary for the purpose of the calico printer, and objectionable on account of the alkali, which is taken up in neutralizing it. A large excess of acid is, however, generally considered as advantageous in the woollen dyes, and a preference may, therefore, be given for those purposes to the first or second preparation.

Dyers are frequently much troubled with this preparation on account of its assuming a concrete and gelatinous consistence, and an opal colour. This effect is sometimes produced by the addition of water; in relation to this subject, Dr. Ure observes that "the uncertainty attending these experiments with the solution of tin in aqua regia seems to depend upon the want of a sufficient degree of accuracy in ascertaining the specific gravities of the two acids, which are mixed, the quantities of each, and of the tin, together with that of the water added. It is probable that the spontaneous assumption of the concrete state depends upon the absorption of water from the atmosphere." This preparation is likewise liable to become milky from the precipitation of a part of the oxide of tin, or, perhaps more properly, a submuriate of that metal. On this account an excess of acid is favourable to its preservation.

It is often desirable to distinguish between solutions of the muriate, and the oxymuriate or nitromuriate of tin, as both are now generally manufactured for the dyer's use in the liquid form, and are not unfrequently mistaken the one for the other, to the loss and perplexity of the dyer, for no two preparations are more unlike in their chemical relations. The muriate of tin forms a black precipitate with a solution of corrosive sublimate, and a purple infusion with a watery decoction of cochineal. The

permuriate, oxymuriate, or nitromuriate, on the other hand, affords no precipitate with the salts of mercury, but gives a scarlet colour to the decoction of cochineal.

Both the oxymuriate, and the solution of the muriate, of tin should be kept excluded from the air; in the former case to prevent the absorption of moisture, and in the latter the absorption of oxygen from the atmosphere.]

COPPER.

Copper is sold in various forms, as in cakes, bean shot, feathered shot, and Japan copper; the latter has its external surface of a fine red colour.

The good quality of copper is shown by its capability of alloying silver, without any diminution of its extensibility under the hammer or rollers. The Swedish copper is the best copper in this respect; but lately the Danes, or rather Norwegians, have forged the Swedish mark, affixed it to an inferior metal, and thus caused a depreciation of that article.

The platers in Birmingham and its neighbourhood, seek after the copper coins of Anne, and the first and second George, and give twice their nominal value for them; these coins, from the dark patina which they have acquired, and their softness, as shown by the considerable obliterations of their impression, appear to have been made of real Swedish copper. Our English copper will not stand this proof, and is of very inferior quality.

Foreign Copper.

The foreign copper ores are usually roasted in piles, smelted through the coals in blast furnaces of different heights, and when the ore is reduced to the state of black copper, it is alloyed with a large proportion of lead, the greater part of the lead sweated out to carry off any small quantity of silver and gold that the copper may contain, and the sweated cakes of copper are submitted to a slight cupellation in a reverberatory furnace, to get rid of the remainder of the lead. So that the treatment is, as usual, much more complex than in England, and the entire process lasts several months; but, in return, for this labour, almost every particle of metal, except iron, is extracted from the ore and brought to sale. Every separate parcel of ore is also carefully assayed as soon as it is brought in, generally by three assayers, the mine proprietors', the smelting-house proprietors', and the workmen's, and the ore mixed in such proportion as that the next round of smelting may form a uniform mixture; by which means, as each separate smelting ought to produce a similar yield of metal, a considerable check is held on the workmen. The slags are also assayed, and mixed in the same manner, for the same purpose.

High blast furnaces are employed to smelt the slaty copper ore of Hesse. These furnaces have two receiving basins, which are used alternately. The

bottom of the fire-room is lined with a mixture of clay and charcoal dust, and is about eighteen feet high.

Nine hundred and twenty-four cubic feet, or about 4080 cwt. of the slate is first roasted in a heap, on a layer of brush wood, and then smelted by degrees, by hourly charges, so that 153 cwt. of the roasted slate, and 522 cubic feet, or 62 cwt. of beech and oak charcoal, pass through the furnace every 24 hours. Every 12 hours one eye of the furnace is stopped up and the other opened. The usual produce in 24 hours is from seven to nine cwt. of copper matt, and some slag mixed with matt, which is flung again into the furnace.

The copper matt is roasted in kilns, holding 250 cwt. ten times successively; by means of 420 fagots of brush wood, 525 cubic feet of beech wood, and 210 cubic feet of beech charcoal. The roasted matt is then smelted again in a lower blast furnace, only seven feet high. Forty-six cwt. of roasted matt with nine cwt. of the slags of the first smelting, and 25 cwt. of beech charcoal produce 16 cwt. of black copper, and 5 cwt. $\frac{1}{2}$ of a matt which is smelted again; the black copper is refined on a forge hearth, as hereafter described.

One hundred cwt. of saleable copper requires, for its production, 5712 cwt. of this slate, and the consumption of 28,674 cubic feet, or 3451 cwt. of beech and oak charcoal, besides a very considerable quantity of wood for roasting the matt, as stated above.

Fig. 169 represents the vertical section of the furnaces, lately brought into use at Fahlun, in Sweden, for smelting copper ore; and fig. 170 is the plan of the same, on the level of the three blast holes, or tuyers, *a*, which form the principal peculiarity in the construction of this furnace. Two common wooden bellows are placed behind the furnace, which, by means of a wooden box, send the blast to the three blast pipes.

This furnace is charged by an opening, *b c*, in the side, to which the workmen get up by means of steps; *D* are plates of sheet iron built in the chimney, for the purpose of stopping the sparks emitted by the fire, which might, otherwise, endanger the burning of the surrounding buildings; a precaution of this kind is usually adopted in the Swedish mine works, on account of their being carried on in wooden buildings. *E* is the receiving basin.

These furnaces are esteemed a great improvement of the common blast furnaces, as consuming less charcoal, and producing more copper than the ordinary kind; hence it is intended, as the present furnaces wear out, to rebuild them on this plan.

In the Hartz, as soon as all the silver is sweated out of the smelted copper by means of lead, the copper is refined on a small forge hearth.

Fig. 171 represents the front view of this forge hearth, or copper refinery. Fig. 172 is the plan at the level of the blast hole, and fig. 173 is the vertical section in the line *a*, *a*, in the plan.

Fig. 169.

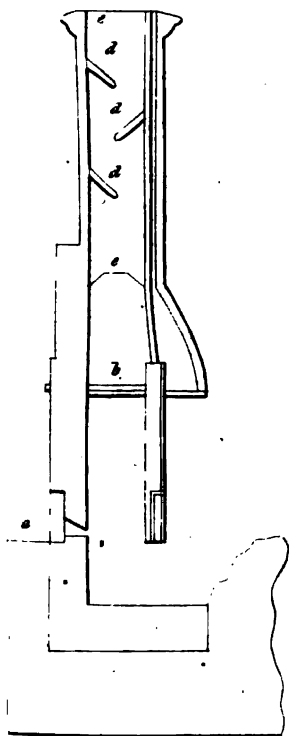


Fig. 170.

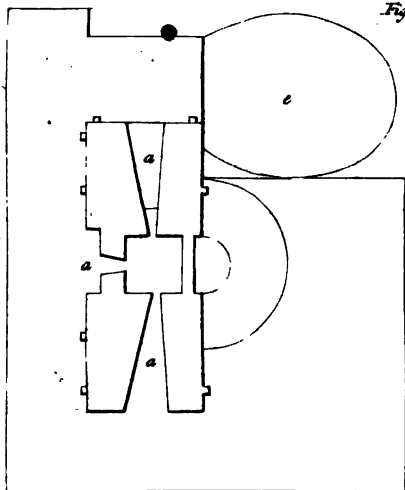


Fig. 171.

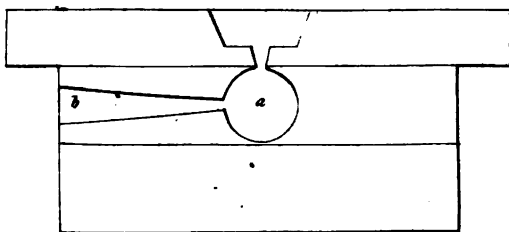


Fig. 172.

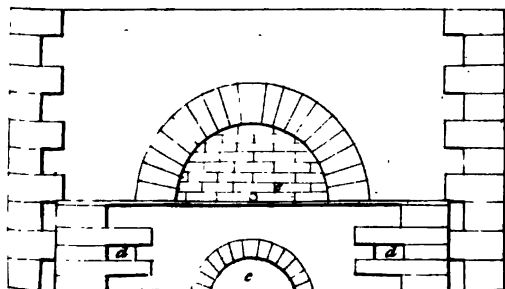
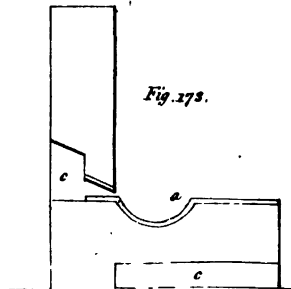
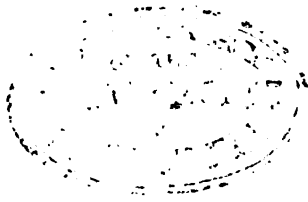


Fig. 173.





A, is the refining basin, lined with a mixture of 2 parts of clay with 1 of charcoal dust; on one side of this basin is a sloping channel, *b*, by which the slags are run off. *C*, is an arch under the refining basin, which, with two other channels, *d*, are to breathe out the moisture. The twyer is at *e*.

The refining of copper on this hearth is performed by smelting it amongst the charcoal; and the blast pipe being inclined downwards, drives the air upon the surface, keeps it in continual motion, and, by favouring the oxidation and vitrefaction of the impurities, the slag is speedily formed, and are run off by the side passage left for it.

At Altenau and Andreasberg a cwt. and a half of black copper from the sweating furnace is refined in 2 or 3 hours $\frac{1}{2}$, according to its impurity, and generally produces 1 cwt. $\frac{1}{4}$ of saleable copper; 1 cwt. $\frac{1}{2}$ of charcoal of resinous wood is consumed.

The purer the black copper, the more may be refined at once, but at the Hartz furnaces not more than 3 cwt. are ever attempted. In the Russian mine works, 8 cwt. of copper are sometimes refined at one time; the refining lasts six hours, and consumes 3 cwt. $\frac{1}{4}$ of charcoal made of resinous wood. They even use still larger hearths, capable of refining 33 cwt. of copper at once, which they let run out by successive piercings of the furnace.

A reverberatory or cupola furnace, similar to that used for cupellation, is also in general use in the Hartz, the Prussian and Saxon Mansfield, Hungary and other countries, for refining arsenical copper matt into black copper, and black copper into saleable copper.

In these furnaces the fuel is burned upon a grate, over a high ash room and the fire room is covered with an arch contiguous to the cupola of the furnace. There is a door by which the bed of the furnace is charged with the matters to be smelted, and another door by which the slags that swim on the melted metal are taken out of the furnace. These furnaces have two eyes in the bed of the cupola, which are occasionally pierced, to let the melted metal run into one or other of the receiving basins, which are used alternately; these basins are lined with a mixture of clay and charcoal dust. There are also two blast holes by which the blast of two bellows are admitted into the cupola. The bed of the cupola is composed of, 1, a layer of slags; 2, a layer of clay; 3, a layer of a mixture of clay and charcoal dust.

At Rammelsberg in the Hartz, the arsenicated copper matt obtained by smelting some of the slags, is remelted in a furnace of this kind, and exposed to the blast of the bellows in order to drive off the arsenic and advance the purification of

the copper. The bed is lined with a mixture of 2 parts of clay and 3 of charcoal. Thirty cwt. of the arsenicated copper matt are then placed on it, and a clear fire of wood is applied for 14 or 15 hours; the metal is then let out of the bed into one of the basins, and 10 or 12 cwt. of black copper are usually obtained. The bed is then prepared afresh, which takes four hours' work, and a new operation begun.

This black copper is farther refined into saleable copper in a similar furnace. 27 cwt. are worked in each operation, which lasts 12 or 14 hours, and yields 20 to 23 cwt. of saleable copper. The bed must be very carefully prepared and dried, so that it takes 6 hours to make it.

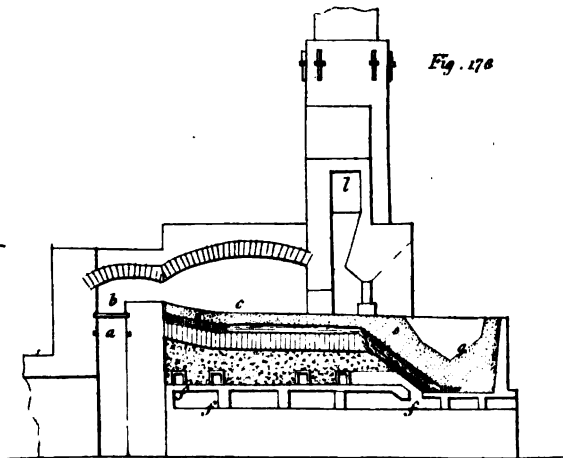
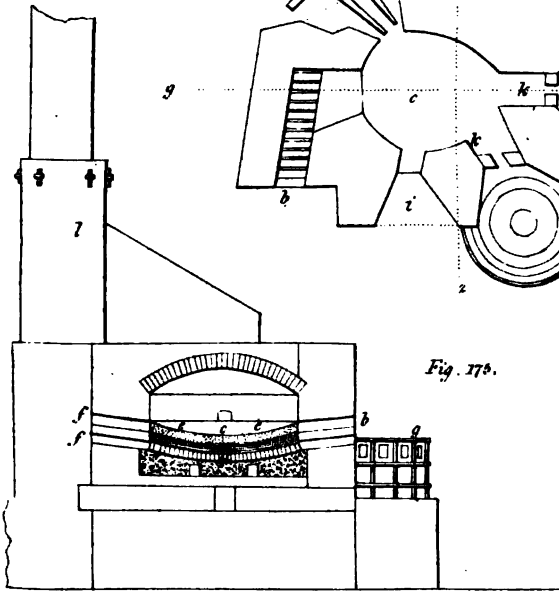
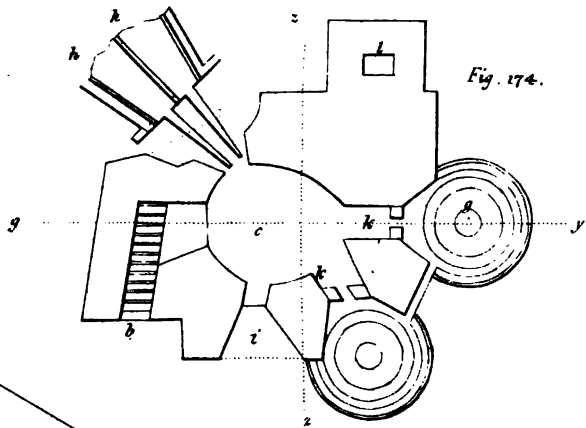
The same kind of furnace is used at Andreasberg for smelting the matts; which are highly loaded with arsenic, and by this means to obtain a purer matt, and lead fit for cupellation.

The French have attempted to improve the construction of these cupola fining furnaces.

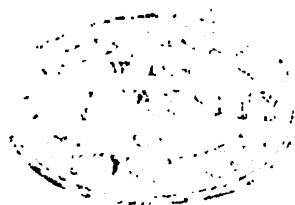
Fig. 174, is the plan of the furnace used in the Lyonnais, in France, for fining copper. Figs. 175 and 176, are vertical sections, in different directions, of this furnace; the first in the line z, z ; the second in the line, y, y .

This copper finery is a reverberatory, bearing a considerable resemblance to the cupolas used in the Hartz, but having a high chimney. A , is the ash-room, and air-draught of the furnace. B , is the fire-room and grate. C , is the bed on which the copper is smelted, the lower part of which, d , is formed of layers of slag of different finenesses, and the upper part, e , of clay mixed with charcoal dust. F , are channels by which the moisture of the bed is breathed out. G , are two receiving basins into which the copper is run, when it is sufficiently refined. H , are two bellows which direct a blast of air on the surface of the melted copper. I , is an opening by which the metal on the bed is stirred, and the slags on its surface drawn out by an iron hoe. K , openings into the chamber, kept stopped during the fining, and then opened to give a passage for the copper to run into the receiving basins, g . L , the chimney.

The copper to be refined is placed on the bed, a layer of straw being first laid down to prevent the bed from being injured by the blocks. The bed of the furnace delineated is calculated to be sufficient to refine 2500 myriagrammes, (550 cwt.) at a time. When the copper is melted, the blast of the bellows is directed on the surface for about two hours, and the slag as it forms is drawn out by the opening for that purpose. The copper being judged to be sufficiently refined, one of the eyes of the furnace is opened, and the copper is allowed to run out into the basin connected with it. As soon as the surface is fixed a little water is thrown upon it, and the crust is taken out; this is repeated until the whole of the copper is cooled and taken off in crusts. Great care must be taken that the surface of the copper is completely fixed all over before the water is thrown on it, as should any of the water touch the fluid metal an explosion would take place.



0 1 2 3 4 5 Pices



English Copper.

The copper ores smelted in the works in South Wales are for the most part raised in the mines of Cornwall and Devon. They consist chiefly of yellow copper ore, or copper pyrites, and the gray sulphuret of copper. The average produce in copper may be stated at $8\frac{1}{2}$ parts from 100 of ore.

The ores are conveyed from Cornwall to the neighbourhood of the coal mines, in Wales, to be smelted. The processes are, as usual in England, very slovenly, as the sulphur is burned to waste, and the after treatment of the ore consists only of alternate calcinations and fusions, so that the copper obtained is very harsh and hard. The furnaces in which these operations are performed, are reverberatory, and of the usual construction. The calcining furnaces, or calciners, are furnished with four doors or openings, two on each side the furnace, for the convenience of stirring the ore, and drawing it out of the furnace. They are commonly from 17 to 19 feet in length from the bridge to the flue, and from 14 to 16 in width; the fire-place from $4\frac{1}{2}$ to five feet across, by three feet.

The melting furnaces are much smaller than the calciners, not exceeding 11, or $11\frac{1}{2}$ feet in length, by $7\frac{1}{2}$ or eight feet in the broadest part; the fire-place is larger in proportion to the body of the furnace, than in the calciners, being usually from $3\frac{1}{2}$ to four feet across, and three or $3\frac{1}{2}$ feet wide. These furnaces have only one door, which is in the front of the furnace.

The charge of ore for a calciner, usually consists of three to three and a half tons. It is distributed equally over the bottom, which is made of fire bricks or square tiles. The fire is then gradually increased; so that towards the end of the process, which lasts twelve hours, the heat is as great as the ore will bear without being fused or baked together. The charge is then drawn out through holes in the bottom of the calciner, of which there is one opposite to each door, and, falling under the arch of the furnace, remains there till it is sufficiently cool to be removed. Water is, at this time, thrown over it to prevent the escape of the finer particles.

The calcined ore, which is black and powdery, is then delivered to the smelters, the charge of the melting furnaces is let down and spread over the bottom, the door of the furnace is put up and well luted. Some slags, from the fusion of the coarse metal or sulphuret, are added.

After the furnace is charged, the fire is made up, and the substances brought into fusion. When the ore is melted, the liquid mass is well stirred; and the substances being in perfect fusion, the smelter skims off, through the front door, the sand

or slags consisting of the earthy matters contained in the ore, and any metallic oxides which may have been formed, which float on the surface. As soon as the metal in the furnace is freed from slags, the smelter lets down a second charge of ore, and proceeds with it in the same manner as with the first; and this he repeats until the metal collected in the bottom is as high as the furnace will admit of; without flowing out at the door, which is usually three charges; he then opens the tapping-hole, in the side of the furnace, and the metal flows into a pit filled with water. It thus becomes granulated.

The slags having been received in sand moulds, the blocks are broken, and any pieces found to contain particles of metal, are remelted. Unless the slag is very thick and tenacious, the copper which they may contain is found at the bottom. What is clean or free of metal is rejected. The granulated metal usually contains about one-third of copper. When the ores are very stubborn or difficult to melt, fluor spar is added to the charge.

The calcination of the coarse metal, the product of the first fusion, is conducted in precisely a similar manner to the calcining of the ore. As it is now desirable to oxidize the iron, the charge remains 24 hours in the furnace, and is repeatedly stirred and turned. The calcined metal is then melted with some slags from the last operations in the works, which contain some oxide of copper, as likewise pieces of furnace bottoms impregnated with metal, the proportion of each varying according to the stock or to the quality of the calcined metal.

The slags from this operation are skimmed off. They have a high specific gravity, and should be sharp, well melted, and free from metal in the body of the slag. These slags are melted with the ore, not only for the purpose of extracting the copper they may contain, but on account of their great fusibility, as being composed chiefly of the black oxide of iron, they fuse readily, and act as solvents. In some cases, the slags from the metal furnaces are melted in a distinct small furnace, with some small coal or carbonaceous matter, and in this case, the slags resulting therefrom are even sharper than those from the metal furnaces, they have a crystalline splendid appearance, and crystals are frequently to be observed in the interior.

The metal in the metal furnace, after the slag is skimmed off, is either tapped into water, or into sand beds. In the granulated state it is called *fine metal*; in the solid form, *blue metal*, from the colour of its surface. The former is practised when the metal is to be brought forward by calcination. Its produce

in fine copper is about sixty per cent. The calcination of the fine metal is performed in the same manner as that of the coarse metal.

The melting of the calcined fine metal is also performed in the same manner as the melting of the coarse metal; the resulting product is a coarse copper, every 100 parts of which, contain from 80 to 90 parts of pure metal.

The roasting is chiefly an oxidizing process. The pigs of coarse copper from the last process, are filled into the furnace, and exposed to the action of the air, the temperature is gradually increased to the melting point, and the expulsion of the volatile substances that remained is thus completed, and the iron or other metals still combined with the copper, are oxidized. The charge is from 25 to 30 cwt. The metal is fused towards the end of the operation, which is continued for 12 or 24 hours, according to the state of forwardness when filled into the furnace, and is let out into sand beds. The pigs are covered with black blisters, and the copper in this state, is known by the name of *blistered copper*. In the interior of the pigs, the metal has a porous honey-combed appearance, occasioned by the gas formed during the ebullition which takes place in the sand beds on tapping. It is in this state fit for the refinery, the copper being freed from nearly all the sulphur, iron, and other substances, with which it was combined.

Another mode of forwarding the metal for the refinery, still practised in some works, is by repeated roastings from the state of blue or fine metal; this, however, is a more tedious method of proceeding.

The refining furnace is similar in construction, to the melting furnaces, only the bottom is made of sand, and laid with an inclination to the front door; the refined copper being taken out in ladles from a pool formed in the bottom near the front door. The pigs from the roasters are filled into the furnace, through a large door in the side: the usual charge is from three to five tons. The heat at first is moderate, so as to complete the roasting or oxidizing process, should the copper not be quite fine. After the charge is run down, the slags are skimmed off; an assay is then taken out by the refiner with a small ladle, and broken in the vice, and from the general appearance of the metal in and out of the furnace, the state of the fire, and other circumstances, he judges whether the toughening process may be proceeded with, and can form some opinion as to the quantity of poles and charcoal that will be required to render it malleable, or to bring it to the proper pitch. The copper in this state is what is termed dry. It is brittle, is of a deep red colour, inclining to purple, an open grain, and a crystalline structure.

In the process of toughening, the surface of the metal in the furnace, is first well covered with charcoal. A pole, commonly of birch, is then held in the liquid metal, which causes considerable ebullition, owing to the evolution of gaseous matter; and this operation of poling is continued, adding occasionally fresh charcoal, until from the assays, which the refiner from time to time takes, he perceives the grain, which gradually becomes finer, is perfectly closed, so as even to assume a silky, polished appearance in the assays when half cut through, and broken, and is become of a light red colour. He then makes farther trial of its malleability, by taking out a small quantity in a ladle, pouring it into an iron mould, and when set, beating it out, while hot, on the anvil, with a sledge hammer; if it is soft under the hammer, and does not crack at the edges, he is satisfied of its malleability, or as they term it, that it is in its proper place, and it is laded out into pots or moulds of the size required by the manufacturer. The usual size of the cakes for common purposes, is twelve inches wide by eighteen inches in length.

The process of refining or toughening copper, is a delicate operation, requiring great care and attention on the part of the refiner, to keep the metal in the malleable state. Its surface should be kept covered with charcoal, otherwise it will go back between the rounds of lading, the cakes being allowed to cool in the pot, and others laded thereon; in this case, recourse must be had to fresh poling.

Over poling is to be guarded against, as the metal is rendered thereby even more brittle than when in the dry state. Its colour becomes a light yellowish red, its structure fibrous. When this is found to be the case, or, as they say, the metal is gone too far, the charcoal is drawn off the surface of the metal, and the copper exposed to the action of the air, till it is brought back to its proper pitch.

Sometimes when copper is difficult to refine, a few pounds of pig lead are added to the charges of copper. The lead acts as a purifier, by assisting, on being oxidized itself, the oxidation of the iron, or any metal that may remain combined with the copper. As the smallest portion of lead combined with copper, renders the metal difficult to pickle or clean from oxide in manufacturing, by hindering the scale or oxide from rising clean from the surface of the sheets, it must be carefully removed. Hence, the copper should be well rabbled, and exposed to the action of the air.

Copper for brass making is granulated that its surface may be increased, so as to combine more readily with the zinc, or calamine.

This is effected by pouring the metal into a large ladle pierced in the bottom

with holes, and supported over a cistern of water. The water may be either hot or cold. When warm, the copper assumes a round form, and is called *bean shot*. When a constant supply of cold water is kept up, the metal has a light ragged appearance, and is called *feathered shot*. The former is the state in which it is prepared for brass wire-making.

Another form into which copper is cast at the smelting houses, chiefly for exports to the East Indies, is in pieces of the length of six inches, and weighing about eight ounces each. These are called *Japan copper*. The copper is dropped from the moulds immediately on its becoming solid, into a cistern of cold water, and thus, by a slight oxidation of the metal, the sticks of copper acquire a rich red colour on the surface.

The other copper ores of England and Wales are smelted in a similar manner.

Solder for Copper.

This is of two kinds, hard and soft.

Hard solder for copper, is usually made of eight pounds of brass, which is melted in a crucible, and a pound of spelter or zinc being heated in another pot, it is thrown into the melted brass, and the crucible covered. In about two minutes the melted metal is stirred, and poured upon a wet birch broom, placed over a pail of water, by which the solder is granulated, and being dried, is kept for use. This solder is very fusible, and yet bears the hammer very well.

When several pieces are to be successively soldered, one after the other, to the same vessel, it is necessary to use solders of different degrees of fusibility, to begin with that which is the easiest melted, and to proceed gradually to the others. For this purpose copper may be melted with various proportions of zinc, from three pounds to sixteen pounds of copper, to each pound of zinc. The more copper is used, the solder is the harder, and the less easily melted.

Soft solder for copper is made of two pounds of tin and one of lead, melted together.

Dutch Brass.

The Commune of Stolberg, situated about six miles from Aix la Chapelle, is eminent for the manufacture of brass plates. The manufacturers consider the copper procured from Cornwall and from Drontheim, in Norway, as the best in quality.

The calamine which is used, is principally obtained from Vielle Montagne, near Aix la Chapelle, and from the territory of Cornelly Munster, near Stolberg.

The crucibles are made about fifteen inches in height, and an inch and a half in thickness. The furnaces in which the copper is smelted, are similar to the brass furnaces used in England, and placed on the ground; their mouth is upon a level with the floor of the workshop; and a deep trough is made below the flat pavement, to serve as a gallery to support the grate, and to admit a current of air to the ash-pit. The form of these furnaces is that of a cylinder, terminated by a narrow neck; they are 14 inches in height, 28 in width, and, at the aperture or summit, 14 or 15. During the operation they are covered with a plate of earth of the same materials with the crucibles.

Into each crucible is then introduced a mixture of the following materials; viz. 40 pounds of copper broken small, 65 pounds of calamine in fine powder, and double its measure of charcoal, also in fine powder. With this mixture the crucibles are filled and placed in two tiers, the one above the other; eight crucibles to each furnace. The crucibles being arranged as above described, a large fire of pit-coal is kept up for the space of twelve hours. The fuel is placed upon an iron grate at the distance of only 20 or 22 inches from that which supports the crucibles. After the fire has been kept up for twelve hours, the scum and charcoal is skimmed off, and a workman lays hold of each crucible with a pair of iron tongs, and throws it forcibly upon a bed of sand, in order to form a hole into which the matter is made to run.

The product of this first operation, is brass of a coarse, brittle, and unequal texture, called *arcost*, which must be subjected to a second fusion, in order to be rendered perfect. For this purpose the same crucibles are again employed. First there are thrown into each three handfuls of the mixture of charcoal and calamine, according to the proportions above mentioned. Over these are placed two or three pounds of brass clippings; then two more handfuls of the first mixture are introduced, together with a piece of arcost about a pound in weight, and these are finally covered with the first mentioned powder. The crucibles being charged in this manner, are placed in the furnaces, from which they are withdrawn after a space of two hours, in order to cast the metal into plates. These plates are cast with the aid of two blocks of very hard granite, five feet long, three and a half broad, and eight inches thick. These are placed one above the other; the upper block is raised by means of a pulley, in order to be washed and rubbed with cow-dung. It is heated before the casting of the metal. In order to give the plate the degree of thickness which is desired, hoops of iron, of different dimensions, are adapted to the inferior stone, which serve to confine the fused metal, and determine its thickness. The first stone is then replaced, and both receive the degree of inclination requisite for facilitating the entrance of the liquid. The plates which are made in this manner, vary in length, breadth, and thickness, from the sixth of a line to eight lines.

From this mixture are produced 53, 54, and sometimes 55 pounds of brass. The plates are exported to different countries, where they are used in the manufacture of clocks and watches.

Any old pieces of this Dutch brass is carefully sought after by our watch and clock makers, as it is not sold in our metal

warehouses. It was found by Doctor Thompson to consist of four parts, by weight, of copper, and one of zinc.

This brass is hammered into leaves, about five times as thick as gold leaf, namely, one-sixty-thousandth of an inch thick, and is sold under the name of Dutch gold, or Dutch metal: it is used for an imitation of gilding, but soon tarnishes, unless defended by varnish.

English Brass.

Calamine is dug out of several mines in the west of England, as about Mendip, which lie about 20 feet deep. It is burnt or calcined in a kiln, or even made red hot; it is then ground to powder, and sifted into the fineness of flour, and mixed with ground charcoal, because the calamine, is apt to be clammy, to clod, and not so apt to incorporate.

About seven pounds of calamine are then put into a melting pot of about a gallon content, and about five pounds of bean shot copper uppermost; the calamine must be mixed with as much charcoal as will fill the pot. This is let down with tongs into a wind furnace, eight feet deep, where it remains eleven hours. They cast off not above twice in twenty-four hours, one furnace holds eight pots, disposed in a circle round a grate.

After melting it is cast into plates or lumps; 45 pounds of raw calamine produces 30 pounds burnt or calcined. Brass shruff serves instead of so much copper; but this cannot always be procured in quantities; because it is a collection of pieces of old brass, which is usually to be got only in small parcels.

The pale Bristol brass has been found, by Dr. Thompson, to consist of only two parts, by weight, of copper, and one of zinc.

Although the old process for making brass is still in use, yet some manufacturers use a portion of spelter or zinc, as well as its oxide, for cementing with the copper.

Spelter in ingots is taken and melted down in an iron pot; the melted spelter is then run through a ladle with holes in it, fixed over a tub of cold water; by which means the spelter is granulated or sholed, and is then fit for making brass. About fifty-four pounds of copper bean shot, ten pounds of calcined calamine, ground fine, and about one bushel of ground charcoal, are next mixed together. A handful of this mixture is put into a casting pot, and upon it, about three pounds of the sholed spelter. The pot is then filled up with the mixture;

and, in the same manner, eight other pots are filled. So that 54 pounds of copper shot, 27 pounds of sholed spelter, about ten pounds of calcined calamine, and about one bushel of ground charcoal, make a charge for one furnace, containing nine pots for making brass.

The pots being so filled, are respectively put into a furnace, and about twelve hours complete the process. From this charge, on an average, there is obtained 82 pounds of pure fine brass, fit for making ingots, or casting plates for making brass pin wire, or brass latten. This brass is of superior quality to the brass made from copper calamine, and is similar to the Dutch brass.

There are several other alloys of copper with zinc, in use; thus various alloys, known by the name of *Prince Rupert's metal*, *pinchbeck*, or *tombac*, are made by adding a pound of zinc to from three to ten pounds of copper.

Sometimes ready made brass is made instead of copper, as in the following instances.

Spelter solder, for brazing iron, copper, or other metals, is thus made:—

Three parts of pan-brass and one part of zinc are taken; the pan-brass is put into a crucible with a little borax. When the brass is melted, the zinc is put in, and the metal stirred with a wire, until nearly all the blue flame subsides; it is then poured out on a piece of sheet iron. To granulate it, it is heated in the fire, and struck on an anvil, which causes it to fall in pieces.

An alloy, called *Bath metal*, is made by adding nine pounds of zinc, to 32 of brass. And an extremely pale, nearly white metal, used by the button makers of Birmingham, under the name of *platina*, by adding five pounds of zinc to eight of brass.

The brothers Keller, who were famous statue founders, used an alloy, 10,000 parts of which contained 9140 of copper, 553 of spelter or zinc, 170 of tin, and 137 of lead. Their castings are excellent, although some are of very large size, as the equestrian statue of Louis XIV. cast at a single jet, by Baltazar Keller, in 1699; which is 21 feet high, and weighs 53,263 French pounds.

The equestrian statue of Louis XV. which was cast by M. Gor, at a single jet, is sixteen feet eight inches high, and weighs 60,000 pounds. Ten thousand parts of its metal contain 8245 of copper, 1030 of spelter, or zinc, 410 of tin, and 315 of lead.

These statues are usually called bronze statues. In an excellent publication, the *Mechanics' Weekly Journal*, the discontinuance of which is to be regret-

ted, may be found a curious account of the gross failures that have lately occurred in France, in casting several large works of this nature.

Cellini, in casting large works, advises the pipe conducting the metal from the furnace to the casting, to pass down to the lowest part of the cast, in order that as the metal rises, it may drive the air in the mould before it, and be less apt to make an imperfect cast.

Brass was well known to the Romans, under the name of orichalcum, who often took advantage of its resemblance to gold; and some sacrilegious characters could not resist the temptation of removing gold from temples and other public places, and chose to conceal their guilt by replacing it with orichalcum. It was thus that Julius Cæsar acted, when he robbed the capitol of 3000 pounds' weight of gold. He was followed by Vitellius, who despoiled the temples of their gifts and ornaments, and replaced them with this inferior metal.

The ancients do not appear to have used brass except for mere ornaments, to resemble gold. It is much more extensively employed by the moderns, and the alloy of copper with tin or bronze, is less extensively used;—because brass is cheaper than the alloy of copper with tin; it preserves its colour longer, and it is easier to work into various forms, especially for philosophical instruments; few of which were, probably, made by the ancients.

Solder for Brass.

The hard solder for brass, is made by melting a pound of brass; and, according to the intended purpose, adding from one to six ounces of zinc previously heated.

The soft solder for brass, is made by melting six pounds of brass, adding first one pound of tin, and when that is melted, a pound of zinc previously heated. The solder is then stirred, and reduced to grains, by pouring it through a birch broom into water.

Gun Metal.

The principal uses of the alloy of copper by tin, are to render copper less oxydable by water, or atmospheric air, to give hardness; to render it sonorous; to render it more fusible; to produce a close texture and whiteness for reflecting light, and to render copper less tough and dingy, or, as the workmen say, *elaggy*.

Copper, alloyed with one of the smaller proportions of tin, by manufacturers, is the metal of which guns or cannon, improperly called brass guns, are made. Different proportions of these two metals are used at different manufactories; but this gun metal seldom contains less than one part of tin to nine of copper. Here as much strength, as is consistent with the preservation of the figure of the instrument during its use, is required; and, if more tin were added, the gun would be liable to be fractured by the explosion; and if less were added, it would be liable to be bent.

Ancient Tools.

Copper alloyed with a somewhat larger proportion of tin than in gun metal in general, affords a metal sufficiently hard and strong for chopping tools, for many useful purposes. Of such proportions, namely, about eight or nine parts of copper, and one part of tin, there is very little doubt all the ancient nations who were acquainted with the alloys of copper by tin, generally made their axes, hatchets, spades, chisels, anvils, hammers, and other tools.

These metals united in these proportions, would afford the best substitutes known at this day for the instruments just mentioned, now commonly made of steel or iron. Accordingly, before the art of manufacturing malleable iron from cast iron was known at all, or, at least, practised extensively, that is, till within these last 400 or 500 years, the alloys of copper by tin, must have been very generally employed.

Celts have been found to contain, in perhaps most instances, the proportions of tin which renders them most fit for the uses to which they were applied. This proportion being considered to be about one part of tin to nine parts of copper.

Ancient Cutlery, and Kitchen Vessels.

Copper, alloyed with a larger proportion of tin than is generally contained in ancient tools; that with one of tin to six or seven of copper, is fitter for cutting instruments, and piercing, boring, and drilling tools, than the metal of ancient tools, because it is harder, takes a finer edge, and yet is sufficiently strong on most occasions; nor do we possess at this day, as it is conceived, any metal which is so fit for knives, swords, daggers, spears, and drills, as this alloy, except iron and steel.

Saucepans, and other ancient cooking vessels, also were made of alloy of copper, by tin in the proportions last mentioned; as the old kitchen utensils were made of cast metal, the tin was added for the purpose of rendering the copper more fusible, and thus, also, for more easily casting of it into the required forms; the tin was also added to render the copper less readily oxydable, and for the colour of this composition. At present brass is preferred for kitchen mortars, and the skillets in which starch or milk is boiled.

From this it will be apparent that tin was infinitely more valuable to the ancients than it is to the moderns. Without this metal, it is not easy to conceive how they could have carried on the practice, and invented the greater part of the useful arts. Tin was even of more importance to the ancients than steel and iron are to the moderns; because alloys of copper by tin, would afford better substitutes for steel and iron, than any substitutes which the ancients in all probability could procure.

We see, also, the importance of Britain, in times more remote, probably than those of which we have any record or tradition; being probably the only country that furnished tin to the progress of cultivation; although the Periplus mentions the tin of Malacca.

If Mr. Locke had been acquainted with the properties of the alloys of copper of tin, and of their extensive use in highly advanced states of civilization among the ancients, he would have known that iron was not the only metal, by the use of which we are in possession of the useful arts, and he would not have said that it is past doubt, that were the use of iron lost among us, we should, in a few ages, be unavoidably reduced to the wants and ignorance of the ancient savage Americans.

Steel was got anciently from those ores only which yield it in a malleable state; as it is probably obtained at this day in India, and called woortz; and as it is also obtained in the northern Circars, and likewise by the Hottentots. As steel was the only state of iron anciently manufactured, it was too scarce, and much too dear for general use; and hence the extensive use of alloys of copper by tin, the best substitute for the malleable state of iron and steel.

Bell Metal.

Copper, united with the proportions of tin last mentioned, is very sonorous; but it is rendered much more so by still larger proportions of tin. It is apprehended the sonorous property increases as the proportion of tin is increased, within certain limits; provided the alloy possess sufficient strength not to be

fractured by the necessary impulse. But as the brittleness increases with the increased proportion of tin, not more than one part of tin is added to three parts of copper, to compose the most sonorous metal that is manufactured, namely, bell metal. The proportion of tin varies in bell metal from one-third to one-fifth of the weight of copper, according to the sound required, the size of the bell, and the impulse to be given. But the alloy just mentioned is too brittle to be beat out into a plate for making a trumpet; and, accordingly, an ancient lituus, which has been made of hammered metal, was found by Dr. Pearson to contain only about one part of tin and 7 parts $\frac{1}{2}$ of copper. But M. Darcet has discovered that bell metal, formed in the proportion of 783 parts of copper, united with 22 of tin, is, indeed, nearly as brittle as glass, when cast in a thin plate, or gong, yet, if it is heated to a cherry red, and plunged into cold water, being held between two plates of iron, that the plate may not bend, it becomes malleable. He has manufactured gongs, cymbals, and tom-toms, in this manner.

Sixty-four ounces of copper, with three of tin, forms a pale metal, ringing very like sterling silver.

Ancient Statuary Metal, or Bronze.

Copper is also united with tin for the purpose merely of becoming more fusible, and of continuing longer fluid, or cooling more slowly while passing from the melted, or fluid state, to the solid state. Such metal is used for making statues, and casts of figures in general, and is called statuary metal, and bronze. The proportions of the two metals are various, probably according to the colour proposed, and the size and figure of the cast, as well as on account of the price of the metals.

The Greeks and Romans consumed vast quantities of copper in casts of figures. They added not only tin but lead to the copper. The proportions given by Pliny are one part of a mixture of equal quantities of lead and tin, to fifteen parts of copper. The use of the lead is not understood, if it was not to save expense. The modern statue founders use a kind of brass in preference.

Bronze Medals.

The superior malleability of copper has made the moderns prefer it in general for coins and medals; but the ancients preferred bronze, and as it resists the injuries of the weather and burial under ground, far better than pure copper, their coins and medals of this metal have come to our hands.

The bronze used for medals is first cast in moulds, and then

finished by the screw-press; hence, as copper does not melt thin enough to take a fine impression, there is a necessity for adding at least 5 parts of tin to 95 of copper, the tin, however, must not exceed 16 parts to 84 of copper; otherwise the extensibility of the copper is impaired. The finest medals are composed of 8 to 12 parts of tin united with 92 to 88 of copper. A little zinc is sometimes added, which causes the surface to acquire a fine green patina.

The dispute in what manner the ancient medals were struck has been the cause of some improvements in the arts.

Mongez, considering that the ancients were but little in the habit of using steel, maintained that their medals were struck with bronzé dies, driven by the hammer upon heated blanks held by pincers.

The bronzé dies used by Mongez were made of 22 to 26 parts of tin, added to 74 or 78 of copper. Some broke after striking 30 or 40 inch and half copper medals, from blanks, others struck 800 before they split; just as some steel dies crack the second or third time of using, while others will strike 14,000 or 22,000 medals without being injured.

Although copper medals could be thus struck from cold blanks by bronzé dies, yet, in striking hot bronzé blanks, the process did not succeed well, although better than when steel dies were used, as the heated bronzé softened the steel so that the fine edges of the impression were speedily effaced, and the surface of the die was calcined and came off in scales. The proper degree of heat to be given to the bronzé was very difficult to ascertain; at a brown red heat the impression was but faint, at a yellowish red the blank cracked on the edges. It was, however, found that bronzé dies and punches are superior to steel when the object to be struck is necessarily heated, or when the die or punch itself is required to be hot.

The other party in the dispute affirmed that the ancient bronzé medals were first cast and then finished by the die. In trying the necessary experiments to determine this point, it was found that the bronzé, or brass, for a mixed metal of 107 parts of zinc, with 892 of copper, was sometimes used, ought to be melted as quickly as possible, so that 10 pounds of metal should not take more than 12 or 15 minutes, and that the moulds should be so thin that the cast bronzé may cool very quickly.

The greatest difficulty is the proper allowance for the contraction of the metal in cooling, when medals are to be copied from a pattern. Jeoffroy applied a thin leaf of lead to the pattern, and made it adhere by means of a burnisher. Puymaurin first tried to cover the pattern with several coats of varnish; but in the end he preferred to heat the pattern, to touch the

parts in relief with a pencil charged with melted bees'-wax, then apply on the wax moist paper of a proper thickness, and finally press the paper with a roll of wet linen. The pattern being thus enlarged in the proper proportion, is moulded in the common casting sand, which may be mixed with some fine powder of clay slate; but Chaudet prefers to mould such small articles in bone-ash. The channels between the main jet and each medal must be thin and wide, that the metal in them may cool before that in the proper moulds; as otherwise there would be danger that the main jet cooling and contracting, the metal might flow back through the side channels, and leave an imperfect impression. The moulds ought always to be smoked by a torch before the metal is run into them.

Mr. Artis, in his Roman Antiquities, has given a figure of a moulding frame, which he found, containing 62 coins of the Emperor Severus, who died at York, 4th February, 209. The whole has the appearance of an earthen bottle, there being two piles of 31 moulds each, with a main jet between them, and a short channel from the main jet to each mould. The neck of the bottle is formed into a funnel leading to the main jet.

The medals being cast, are finished by dies with a screw-press; as the relief is nearly complete, a very few strokes of the press is sufficient to finish them, and they do not require the heats that are required to be given to medals when struck from blanks, as in this case inch and half medals, even of pure copper, require 5 or 6 heatings, and 10 or 12 strokes; inch and $\frac{1}{2}$ medals, 7 or 8 heatings, and 14 or 16 strokes; 2 inch medals, 12 or 16 heatings, and 24 or 32 strokes; and 2 inch and $\frac{1}{4}$, or larger medals, 30 or 40 heatings, and from 90 to 120 strokes of the press.

Speculum Metal.

The composition in common use which contains the greatest proportion of tin, is called speculum metal. The requisites of this metal are compactness, uniformity of texture, whiteness, sufficient strength to prevent its cracking in cooling, and to bear polishing without breaking.

Mudge found the whole of these properties attainable in the greatest degree by a little less than 1 part of tin with 2 parts of copper. But for very large instruments, such as the 40 feet telescope of Herschel, the proportion of tin must be less than in small instruments, on account of the brittleness.

Edwards affirms that different kinds of copper require different doses of tin to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the metal will be yellow; if it be too great, the metal will be

gray blue and dull. He first melts the metals together, and pours the alloy into cold water, to granulate it. Then melts the metal again, and casts the speculum with its face downwards, takes it out while red hot, and places it in hot wood-ashes to cool very gradually, as otherwise it would break.

Little first melts 4 parts of brass pin wire, with an equal weight of tin, and casts it into an ingot. He then melts 32 parts of the best bar copper, along with some black flux, and puts into it the ingot of brass and tin; when this is melted, he adds twelve parts and a half of tin, and, after that, a part and a quarter of white arsenic; the whole is then poured into cold water to granulate it, and again melted when the speculum is to be cast.

Some add silver to speculum metal, but Little found that it made the metal too soft, and hindered it from receiving the highest degree of polish, unless the compound metal was extremely brittle.

Whitened Copper, or False Silver.

This metal may be formed by mixing white arsenic with any common oil, pearl-ash, and charcoal powder; and laying the mixture in alternate beds with granulated copper, in a covered crucible. A gentle heat is given at first, but afterwards it is raised quickly to the melting heat of copper; and as soon as the mixture is melted it is poured out.

A pound of copper, in bean shot, mixed with an ounce of neutral arsenical salt, a little borax, previously calcined, charcoal dust and glass in powder, being melted, also produce a white metal of this kind.

Or it may be made in a more direct manner by putting 10 parts of copper shreds into a crucible, along with one part or rather more, of regulus of arsenic, covering the crucible, and melting the whole together.

Pak Fong, or Chinese White Copper.

This compound metal is smuggled in blocks of 10, 20, or 40 pounds, from China; 1000 parts of pak fong contain, according to the analysis of Dr. Fyfe, 400 of copper, 254 of zinc, 316 of nickel, and 26 of iron. It is, probably, a speiss obtained by smelting some ore, or mixture of ores. It is sold in China for about $\frac{1}{4}$ its weight in silver, and is strictly forbidden to be exported.

It has been confounded by some with tutenag, or zinc.

Violet Metal.

This metal is made by melting together three pounds of copper shreds, with one of regulus of antimony. It is brittle, of a violet colour, and takes a very fine polish.

Gilt Copper.

A metal composed of about six parts of copper, and one of brass, is the best for gilding, as copper does not readily take the amalgam, and from its colour requires more gold than when brass is added. A second coat of gilding is preferable to the same quantity of gold laid on at once.

The amalgam of gold used in gilding, contains about two parts of quicksilver, with one of gold.

The copper to be gilt, is first cleansed by dipping it in a mixture of aqua fortis, with four times, or more, as much water. Large articles are first heated, then dipped in a strong solution of sal enixum, or sal ammoniac, and then in the weak aqua fortis. The surface being thus pickled, is cleansed by a brush wheel of brass wire; or for very fine work, by a hand brush.

That the amalgam may spread equally over the surface of the copper, it is first dipped in a solution of quicksilver in aqua fortis, and then the amalgam is applied with a piece of flattened copper wire, which is occasionally dipped in the solution of quicksilver, and then the amalgam touched with it, and the small quantity taken up rubbed over the article.

Another method is to mix the amalgam with more quicksilver, and some acid, and to dip the article into the mixture.

The gold being thus spread evenly over the surface of the copper, the quicksilver is evaporated by a gentle heat, the article being exposed over a small stove, under a chimney having the front built up, and closed with a window sash, so that the workman may see how the work goes on, without being exposed to the fumes of the quicksilver. The articles if large, are held in pincers, or if small, a number are put into an iron pan, or cast pot; and when sufficiently heated, the larger articles are rubbed with a soft bristle brush, and the smaller articles are shaken in a bag, and well stirred about with a brush. As the gilt metal has still a dull appearance, it is polished by rubbing it with a wire brush with small beer, or ale grounds.

The colour of the gilt copper is heightened by heating it afresh; and if any spots appear of a different colour, they are touched with a stick dipped in aqua fortis. It is then thrown into very weak aqua fortis, which will cause any spots where the gold is deficient to appear. The gilt copper is again polished with the scratch brush; and if a very high polish is required, burnished with a blood-stone and water.

If a very high colour is required, the work is covered with *gilders' wax*, composed of eight ounces of bees' wax, and three each of red chalk, or red ochre, and of calcined verdi-

gris, with an ounce of dried borax; and being held over the fire till the wax smokes, and is ready to take fire, it is then dipped in water, and the wax cleaned off with the wire brush and beer.

For a still higher colour, the work is afterwards spread over with a paste composed of equal parts of sal ammoniac; saltpetre, blue vitriol, and a half part of crystallized verdigris, made up with water, and then heated till it smokes; after which it is treated as with the gilders' wax.

Dead yellow gilding, presenting a frosted surface, without any polish, and of a beautiful yellow colour, is produced by a saline preparation formed of six ounces of saltpetre, two of copperas, and one each of white vitriol and of verdigris. The work being covered with this paste, is thrown into weakened aqua fortis, and the ebullition produces the dead or matted appearance.

The following alloys of copper are used at Birmingham for gilding upon. Four parts of copper, melted with one of Bristol, or pale yellow brass, and then remelted with 14 ounces of tin to each pound of copper that was used. For common articles, 3 parts of copper, 1 of Bristol brass, and 4 ounces of tin, to each pound of copper. If the articles are to be highly polished, half the tin is taken away, and supplied by regulus of antimony. If the articles are wished to be of a pale colour, half or even two-thirds only of the copper may be put in. Compound metals, nearly the colour of gold coin, which of course require but little gold for gilding, are made by melting 2 parts of Cheadle, or dark brass, 1 of copper, with a little Bristol brass, and a quarter of an ounce of tin, to each pound of copper, or 16 parts of tough cake copper, are melted with 5 of spelter or zinc.

Plating of Copper with Gold.

Ingots of copper or brass, are plated with gold for the purpose of rolling out into sheets, by first cleansing the surface of the copper, then placing a piece of gold upon it; hammering it out to cover the surface; binding it on with wire that it may not slip; soldering the edge of the gold plate with silver filings, mixed with borax, by exposing the ingot to a sufficient heat; the ingot may then be rolled out into sheets.

Cold Gilding of Copper or Brass.

For cold gilding by friction, a fine linen rag is steeped in a saturated solution of gold, till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterwards burned

to tinder. Now, when any thing is to be gilded, it must be previously well burnished; a piece of cork is then to be dipped first into a solution of salt in water, and afterwards into the black powder, and the piece, after it is burnished, rubbed with it.

Grecian Gilding of Copper or Brass.

For this gilding, equal parts of sal ammoniac and corrosive sublimate are dissolved in spirit of nitre, and a solution of the gold made with this menstruum. Upon this the solution is somewhat concentrated; and the metal is put into it, or brushed over with it. The surface of the metal is rendered quite black by the liquor; but on being exposed to a red heat, it assumes the appearance of gilding.

Plating of Copper with Silver.

The ingot of copper is first filed, and its surface left rough; the rolled silver is annealed, pickled in weakened spirit of salt, planished and cut to fit the surface of the copper ingot, which is dipped in a solution of borax, and strewed with powdered borax before the silver is applied, which is then bound on the copper with wire; and on being exposed to a sufficient heat, the metals unite, and the plated copper may be rolled out into sheets.

Copper may also be plated by merely burnishing silver leaf upon it, while it is hot; this inferior kind of plating is called *French plating*.

In cutting out the rolled plated metal into pieces of the required forms and sizes, there are many shreds or scraps unfit for any purpose but the recovery of the metals by separating them from each other. For this purpose two modes were practised: one by melting the whole of the mixed metals with lead, and separating them by sweating, and cuppelling. The second, by dissolving both metals in oil of vitriol with the help of heat, and by separating the sulphate of copper by dissolving it in water, from the sulphate of silver, which is afterwards to be reduced and purified.

The method invented by Mr. Kier, is now commonly practised by the manufacturers in Birmingham, and is more easily executed than any of the other methods. The pieces of plated metal are put into an earthen glazed pan; some oil of vitriol, mixed with one-eighth or one-tenth its weight of saltpetre is poured upon them, and they are stirred about that the surfaces may be frequently exposed to fresh liquor, and the action is assisted by a gentle heat. When the liquor is nearly saturated, the silver is to be precipitated from it by common salt, which forms a precipitate easily reducible by melting it in a crucible with a sufficient quantity of pearl-ash, and, lastly, by refining the melted silver, if necessary, with a little saltpetre thrown upon it. In this manner the silver may be obtained sufficiently pure, and the copper will remain unchanged.

Otherwise the silver may be thrown down in its metallic state, by adding to the solution of silver, when poured off clear, a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper.

Silvered Copper or Brass.

Copper may be silvered over by rubbing it with the following powder; two drams of tartar, the same quantity of common salt, and half a dram of alum, are mixed with fifteen or twenty grains of silver precipitated from its solution in aqua fortis by copper, and then brushed off and polished.

Silvering by fire is performed in the following manner: half an ounce of silver, common salt and sal ammoniac, of each two ounces, and one dram of corrosive sublimate are triturated together, and made into a paste with water. With this, copper utensils of every kind that have been previously boiled for a short time with tartar and alum, are rubbed; after which they are made red hot and polished. In this manner is done the cheap silvering of the saddler and harness-makers. The above mentioned precipitate of silver may also be laid on another way with borax or mercury, and made to adhere by fusion.

Tinned Copper.

Copper is tinned by scraping the surface, heating the plate, sprinkling a little resin and sal ammoniac upon it, pouring some melted tin, or a mixture of tin and lead upon the copper, and spreading it evenly over the surface by means of a many folded cloth.

Copper is tinned for the purpose of defending it from the action of the acids and fats used in cooking.

The doubts which have been raised for years past respecting the wholesomeness of tinned copper, and those to which the accidents occasioned by glazed pottery have given birth, caused an alarm to society to be created by morbid sensibility, and many fancied remedies have been proposed for the imaginary evil.

Maloian, in 1742, proposed to employ spelter or zinc for this purpose; but he and his followers forgot that although zinc is harder than tin, yet it is still more easily attacked and dissolved by acids.

Of late the French have begun to tin their copper vessels, with tin hardened by iron. For this purpose, they melt together eight pounds of tin, and one of iron turnings, or small nails, in a crucible; adding a handful of salt, or of pounded glass, to keep the air from the metals while they are melting.

Rinman for the same purpose has proposed several cheap enamels, for lining copper and iron vessels, mostly composed of fluor spar, gypsum, and common glass in various proportions.

White Brass Pins.

The operation of whitening may be performed by several different acids; but the acids usually preferred are white and red argol, or cream of tartar.

First, after the heads are cast upon the shafts, the quantity of pins intended to be whitened at once, generally about 50 pounds, are put into a colander; and this is dipped into a mixture of about one gallon of oil of vitriol, to six gallons of water, and the pins lie in the same mixture about half an hour, and the acid that hangs about them is removed by dipping the same vessels into clean water two or three times.

After this, about 25 pounds of pins are put into a common scouring barrel, and along with them about 50 pounds of small grain tin, six ounces of red argol, and three gallons of warm water, and being turned for one hour, they will be perfectly clean.

They are then dipped into a mixture of about one pound of blue vitriol, in two gallons of cold water. This gives the pins a complete cast of copper.

After this operation a layer of about six pounds of pins, dipped as above, are laid at the bottom of a copper boiler, and at the top of them, a layer of about seven or eight pounds of fine grain tin, rather small, and so on, first the one and then the other, until the whole 50 pounds of pins are put into the copper boiler. At the top a covering half an inch thick, of the small grain tin is laid, except that upon one side a small opening is left to enable the workman to introduce water to the bottom of the vessel, without disturbing the tin at the top. A sufficient quantity of cold water is poured into the copper vessel to fill it, or nearly, and next a quantity of small grain tin, to fill up the small opening left in the vessel as above mentioned.

When the water becomes a little warm, there is put into it by a dredging box, four ounces of red or white argol, or four ounces of cream of tartar, pounded fine, and it is boiled an hour. Then the tin and pins are thrown together in cold water, and the pins separated from the tin by a colander. This operation is repeated until the colour of the pins is perfect, they are then dried off in warm bran.

Blue Vitriol.

Blue vitriol, when manufactured, is made by heating plates of copper red hot in an oven, the oxide that is formed on their surface is beat off, and this repeated until the whole of the cop-

per is reduced to oxide. The oxide is boiled in oil of vitriol, and when the dissolution is completed, boiling water is added, and the blue liquid run off into leaden vessels, and left to crystallize by gradual cooling.

The waters that run through copper mines become impregnated with this salt, and are sometimes boiled down and crystallized; but in general it is found most advantageous to throw old iron into the water, which separates the copper and is dissolved in its place.

Blue vitriol is used to bronze iron, and to prepare several blue and green colours.

Blue vitriol is the sulphas cupricus cum aqua of Berzelius, or $\text{Cu: S:} \frac{2}{3} + 10 \text{ Aq. equal to } 3,126,380$. Dr. Thomson estimates the sulphate of copper as $\text{Cu: S:} + 5 \text{ Aq. equal to } 15,625$.

Blue Verditer.

The greatest part of this is made by dividing 240 quarts of boiling blue vitriol water at 35 deg. Baumé; or sp. gr. 1.299, in four open tubs, and adding 180 quarts of boiling muriate of lime water, at 40 deg. Baumé, or sp. gr. 1.357. The mixed liquors are to be well stirred together, and then left for 12 hours to settle. A portion of the clear liquor is then divided into two parts, and examined by adding blue vitriol water to the one, and muriate of lime water to the other, whether the mutual change in the liquors is complete; if not, the deficient liquor must be added, observing that there is less inconvenience in a small excess of blue vitriol than of muriate of lime.

The clear liquor is then to be drawn off, and there is poured upon the settling of sulphate of lime the second washings of a former operation, at 8 or 10 deg. Baumé; the whole is stirred, then left for 12 hours to settle, and the clear liquor poured off and added to the former.

The settling is then thrown upon hempen-cloth strainers, and washed with the last washings of a former process and water, until the liquid that passes is not more than 3 deg. Baumé. The last washings are set by for washing the settling of future processes. There is obtained by this means about 670 quarts of green liquor at 20 deg. Baumé.

Two cwt. of quicklime are in the mean time slaked by adding 60 gallons of water; and the whole first passed through a wire sieve, and then ground fine in a stone mill. A cwt. and quarter, or half, of this cream of lime is added to the above green liquor, the whole well stirred, and then left to settle. The clear liquor is examined, and if ammonia water added to it produce a full blue colour, more of the cream of lime must be added, until the trial by ammonia water produces only a

pale blue tinge. The settling is then put upon linen filters and washed first with the washings of former operations, and then with water, until the liquid becomes weaker than two deg. Baumé. The liquid that runs through, and is 10 deg. Baumé, is boiled down to 40 deg., and the muriate of lime crystallized for future processes; that liquor which is weaker than 10 deg. is also reserved for future use. By this means there is obtained about half a ton of wet green; 100 parts of which generally contain 27 of dry colour, as may be ascertained by drying a small portion.

A quarter cwt. of this wet green, more or less, according to its content of dry colour, is put into a deal trough, two pounds of cream of lime added, the whole quickly stirred together; a pint and a half of pearl ash-water, at 15 deg. Baumé, is then poured in, the whole ground as quickly as possible in a mill.

Two saline solutions are in the mean time prepared. One of half a pound of gray, or Egyptian sal ammoniac, in a gallon of water; the other of a pound of blue vitriol, also in a gallon of water. The colour, as soon as it is ground, is put into a stone bottle, the blue vitriol water is first added, and immediately afterwards the sal ammoniac water; the bottle is then corked, well shaken, and rosined; 24 of these bottles are usually prepared as a day's work.

At the end of four days four of these bottles are emptied into a brandy cask holding about 100 gallons, and this is filled up to within a few inches of the bung hole with clear water. The mixture is well stirred, and a cock being placed so as to leave about one-third of the cask for the settlings, the water is drawn off, and replaced with fresh, once a day in winter, and twice a day in summer; a fresh stirring being given each time, and the bung hole kept covered. The colour is washed in this manner until the liquor drawn off does not change the yellow colour of paper stained with turmeric to a green, which generally happens after 8 or 10 washings. Each cask produces nearly a cwt. of superfine wet blue verditer, which is used in large quantity by the paper-hanging manufacturers.

A colour of inferior quality, called fine blue verditer, is prepared by putting in an additional pound of lime, and using white or European sal ammoniac; and another still inferior, called blue, No. 1, by using four pounds of lime instead of two, and a pound of sal ammoniac instead of half a pound.

The superfine blue, and fine blue, are also prepared as lump colours by drying the wet paste in the shade.

Refiners' Verditer.

The refiners prepare verditer from the bluish green liquid left

on separating silver from its solution in aqua fortis, by putting the solution into large wooden bowls lined with pitch, along with great plenty of water, and slips of copper. Dr. Merrett says they put a cwt. of whiting into a tub, pour the copper liquor upon it, and stir it every day, till the liquor loses its colour. The liquor is then poured off, and fresh added; this is repeated until the whiting has obtained the proper colour; the clear liquor poured off is boiled down and used instead of saltpetre for making aqua fortis. Dr. Lewis says this process is very uncertain, and that even the most experienced workmen frequently fail entirely, or produce a green colour instead of a blue; it succeeds best when the liquor is warmed before it is poured on the whiting.

Mr. Pelletier advises to mix powdered lime with the nitric solution of copper, taking care not to put so much lime as to alter the whole of the nitrous liquor, then to wash the settling, and grind it with lime in the proportion of an ounce or ounce and half of lime to each pound of the settling.

Rough Verdigris.

This is manufactured by the farmers' wives and daughters near Montpellier, in France, to supply themselves with pocket money.

The copper used is about one-twenty-fourth of an inch thick, cut into pieces about five inches long, three wide, and weighing about four ounces each; it is well hammered, to prevent its coming off in scales, when the greened surface is scraped.

Grape stalks, and weak wine, were formerly used to cotton the copper; but at present they use only the cake left after pressing the grapes, which was then flung on the dunghill. This cake is kept until a leisure time occurs, by pressing it very close in casks; when used, it is taken out and aired by placing it very loosely in casks, or in earthenware pans, covered with straw caps. It heats and exhales an acid odour; if the heat grows too violent, the cake is taken out and cooled, by spreading it abroad: sometimes in cold weather it does not heat kindly, but grows putrid, and is spoiled.

After three days' heating a trial is made, by burying a copper plate in the cake for 24 hours, whether the cake cottons the copper properly; if not, a fresh trial is made. When the cake is in proper train, the copper plates to be changed into verdigris are heated, so that they can scarcely be taken hold of by the hand, and placed in layers along with the cake, in earthen pans, the bottom and top layers being made of cake, and left for a fortnight or three weeks. If there were any copper plates left from a former operation, the verdigris upon them is carefully washed

off, and they are dried; as otherwise, the verdigris left on them would become black.

When the cake becomes white it is time to empty the pans, and by this time the surface of the copper is covered with loose silky crystals. These plates, when taken out, are placed upright upon sticks in a cellar, supported one by the other, and after two or three days they are dipped in water and replaced for about a week, when they are dipped again into water, and this is repeated weekly for six or eight weeks.

Every 30 or 40 pounds of copper yields five or six pounds of the moist fresh rough verdigris, which is now scraped off the plates with a knife, and packed either in large wooden boxes, or in small white leather bags, about a foot each way. That packed in the bags is exposed to the sun until it becomes so dry as not to allow a knife to enter it: by this drying it loses about half its weight.

The copper plates are sometimes totally changed into rough verdigris in a couple of seasons; at other times they will take nine or ten seasons.

The boxes of fresh moist verdigris are sold for making crystallized verdigris.

Verdigris is also manufactured at Grenoble.

Verdigris is either of a blue or green colour. Blue verdigris contains 4334 parts of peroxide of copper, 2745 of acetic acid, and 2921 of water; 2345 of which last was driven off by drying in the heat of boiling water. The green verdigris contains about 44 parts of peroxide of copper, 32 of acetic acid, and 24 of water; of which last, 10 were driven off by a heat of only 140 degrees. Berzelius considers them, from the ease with which they are changed by a slight heat, or the addition of either cold or hot water into other salts of copper, as $\text{Cu} \cdot \text{A}^2 + \text{Cu} \cdot \text{Aq}^2 + 10 \text{ Aq}$; but Thomson, as $\text{Cu} \cdot 2\text{A} - + 6 \text{ Aq}$ only, equal to 23,000.

Crystallized Verdigris.

This salt is also frequently called *French Verdigris*. It is manufactured by dissolving as much moist fresh rough verdigris in distilled vinegar, as the acid will take up by boiling. When saturated, the solution is poured off clear into another copper boiler, and evaporated until ready for crystallization.

A number of sticks, a foot long, are split crosswise at one end, to within two inches of their other end; the four branches are kept wide open by small sticks. These sticks are hung by threads to bars placed across the top of the boiler, so that the crystals may adhere to them, by which means there are formed conical masses of crystals, weighing five or six pounds each.

It takes about three pounds of moist rough verdigris to make a pound of crystallized verdigris.

The principal use of this verdigris is as a show-toy in the windows of druggists and colourmen's shops; it is also used to make a wash-colour for maps, and to make the spirit of verdigris for smelling bottles.

This, the *acetas cupricus cum aqua* of Berzelius, he considers as $\text{Cu: A}^{\text{c}} + \text{Aq. or } 2,511,900$: and Thomson, as $\text{Cu: A} - + \text{Aq. or } 12,375$.

Vert de Mitis, Schweinfurt Green, or Vienna Green.

Dissolve 1lb. of verdigris in vinegar; dissolve also 1lb. of white arsenic in a sufficient quantity of water; pour the solution of arsenic into that of the verdigris; if a dull green sediment falls, more vinegar must be added, until the sediment is dissolved. The liquor is then to be boiled, and after some time very fine green crystals fall down: when they do not seem any longer to increase, they are to be separated, washed with cold water, and dried.

This colour has a bluish tinge, but it may be prepared of a deeper shade, and of a yellow tinge, by dissolving 1lb. of common potash in a sufficient quantity of water; then 10lb. of the paint, prepared as above described, is to be added, and the mixture gently heated, by which means the colour gradually changes to a yellowish tint. If it be boiled too long, however, the paint acquires a colour similar to that of Scheele's green, but it is always a superior article.

In the preparation of the original paint, the liquor poured off the green crystalline grains must be differently treated according to its nature, which varies according to circumstances. If the liquor still contains much copper, some arsenic liquor must be added; if the liquor contains an excess of arsenic, some fresh solution of verdigris is to be added, and the process carried on as before. Sometimes there is an excess of vinegar, and in that case it may be employed along with some fresh vinegar, to dissolve a fresh parcel of verdigris. In like manner, the liquor left in the preparation of the yellowish green paint, may be used in the preparation of Scheele's green.

Lime Acetate of Copper.

This is prepared by Mr. Ramsay, of Glasgow, for the calico printers. It is a fine deep blue salt, which is soluble in water, and when kept for some time, the crystals become spotted with white crusts of acetate of lime.

The manner in which he prepares it, is unknown; but Dr. Thomson found 2775 parts of it to contain 975 of acetate of lime, 1125 of acetate of copper, and 675 of water; hence, he considers it as $\text{Ca: A} - + \text{Cu: A} - + 6 \text{ Aq.}$

Scheele's Green

Is made by dissolving two pounds of blue vitriol in three gallons of boiling water, and also two pounds of pearl-ash, and eleven ounces of white arsenic, in another gallon of water, filtering the two solutions, and adding the solution of blue vitriol to the other by degrees while hot, and washing the sediment with cold water.

Other green colours, of various shades, may be made by dissolving blue vitriol in water, along with Epsom salt, alum, or copperas, in various proportions, and pouring pearl-ash water into the solution as long as any sediment falls down; the liquor is then to be strained, and the sediment to be washed.

[Nitrate of Copper.]

This salt is considerably used by the calico printers. One hundred pounds of single aqua fortis will dissolve ten and a half

pounds of copper, and make one hundred and three pounds of a solution of nitrate of copper at 64° Tweedale's hydrometer, which is the strength generally adopted by the printers, either for a verdigris green, (Scheele's green,) or the *resist paste*. To make the crystallized nitrate, double aqua fortis should be employed, adding the shreds of copper as fast as the effervescence will permit. The water bath is then employed for farther evaporation.]

TOUGH IRON, OR MALLEABLE IRON.

This very useful metal, is sold in England of various qualities, and in various forms, suited to the uses to be made of it.

Swedish iron, all of which is manufactured with fir charcoal, and preserves its superiority over every other kind.

English wrought iron, mostly manufactured with coke, and of inferior quality.

No. 2 iron, is a better kind of English iron.

No. 3 iron, is the best kind of English iron.

In regard to the most usual forms in which tough iron is sold, they are sheets of various breadths and thicknesses. Bars, usually ten feet long, and from six inches wide, and three-quarters of an inch thick, down to one inch and a half wide, and nine-sixteenths of an inch thick; squares and bolts, or rods, of the same length, from three inches thick down to half an inch. Wire from seven-sixteenths of an inch, down to the smallest that can be drawn.

Tough iron being manufactured from pig iron, it is necessary to exhibit the manufacture of pig iron, although it is a compound metal, before that of the simple tough iron, its principal ingredient.

Four methods are in ordinary use for smelting iron ores. 1. The Catalan forge; 2. The single block furnace, or German *stueck oven*; 3. The flowing furnace, or German *floss oven*; and 4. The high furnace, worked either with charcoal or coke.

The propriety of employing one or other of these methods of smelting iron ores, depends entirely upon local circumstances, and the capital that can be employed.

Tough iron is also either *perfectly malleable iron*, both hot and cold, as the Swedish iron, and the best kind of English iron, finished by the tilting hammer at the refinery. 2. *Hot short iron*, which works well when cold, but is brittle and untractable when hot. 3. *Cold short iron* does not work well when cold, but is very malleable when heated.

Charcoal Pig Iron.

The single block furnace, or stuck oven, is the smallest furnace used in manufacturing charcoal pig iron. The fire room is ten or fifteen feet high. This fire room is either conical or egg-shaped.

Experience having taught the workmen in the Catalan forges, that there was some advantage in heightening the sides of the forge, in order to concentrate the heat, and smelt more ore at a time; the iron masters followed up the practice, and thus produced these furnaces, which have only two openings at their lower part. One of these openings is the twyer, by which the blast is admitted, the pipe of which is inclined towards the bottom of the crucible of the furnace; and the other opening is an eye, through which the slags run out as soon as the crucible is sufficiently filled; and when metal begins to flow by the same opening, thus showing that the crucible is full, the operation is finished, and the fire is blown out.

As the side walls of this furnace are too deep to allow the pasty mass of smelted iron to be taken out by the mouth at top, and there is no opening at the lower part for that purpose, there is a necessity for breaking down one of the side walls to get out the iron. Until 1762, these furnaces were used throughout Styria to smelt sparry iron ore, and brown oxide of iron of that country, and some are still at work.

In smelting iron ore in the furnace, the blast pipe is first placed; this is usually made of clay spread upon a wooden mould, and is moveable so that it may be raised up as the crucible fills, even to two feet and a half, above the bottom. The eye is then arranged, so that it may be raised gradually, and the hole in the wall, by which the iron was taken out, is built up.

The furnace is then filled to one-third its height with charcoal, and the fire lighted. About six cubic feet, or half a cwt. of charcoal, with a little ore, is then added occasionally, until the furnace is filled. The bellows are then set gently to work, and after five or six hours' firing, the furnace is usually sufficiently hot to allow the full charge of ore, namely, one cwt. of brown oxide with each charge of charcoal. These charges are continued for ten or twelve hours, and then the fire is blown out, and the wall broken down to get out the iron.

During the smelting, the blast pipe is moved two or three times; and the eye raised up as often, to allow more room for the metal below it. The mass of metal weighs about 15 or 20 cwt.; and from 3 to 6 cwt. runs out at the eye with the slags.

The iron yielded by these furnaces is very pure, and indeed half refined; the produce is about 35 parts in 100 of the washed brown oxide. The refining is finished on a small forge hearth, in which it loses one-tenth of its weight. To obtain one cwt. of iron, 25 cubic feet, or 2½ cwt. of charcoal of resinous wood, and the refining of 1 cwt. of this iron into thick bars, 1½ of

charcoal. So that for obtaining 100 pounds of bar-iron, 415 pounds of charcoal are required in the whole.

Sparry iron ore, mixed with brown oxide of iron, yields 25 pounds of raw iron from 100 of ore, and consumes $3\frac{1}{2}$ cwt., or 36 cubic feet of charcoal of mixed wood; so that to obtain 100 pounds of bar iron, 538 pounds of charcoal are required in the whole.

Pig iron is now seldom made in this manner, and few of these furnaces are in blast in any country.

In these kinds of iron-smelting furnaces, which are called by the Germans *floss ofen*, and sometimes *blau ofen*, or *schuer ofen*, the fire room is from 15 to 25 feet in height, with a swelling out a little below half its height, as in the boshes of the high furnace. Towards the bottom of the fire room is an eye or hole, and sometimes two, one above the other, to let out the metal and slags; but which are kept closed, with an iron plug coated with clay, except at the time when the furnace is to be emptied. In consequence of this convenient mode of extracting the metal, the fire is kept up for months together.

A charge for these furnaces is usually $9\frac{1}{2}$ cubic feet of charcoal of soft wood, and $1\frac{1}{2}$ cwt. of prepared ore, generally sparry iron ore, or brown hæmatites. The furnace being brought into heat, 100 of these charges are flung in every 24 hours. At the end of every 20 charges, the lower eye is opened, and the metal allowed to run out; the usual produce is 12 cwt. each piercing, or 420 cwt. weekly, sometimes it amounts to 500 cwt. The slags being partly removed from the surface of the metal, a little water is sprinkled upon it; and by this means it is obtained in thin cakes, which are taken off as fast as they are formed.

There are also made between each running two openings of the upper eye hole, by which means a great part of the slag is got rid of.

The iron yielded by these furnaces, is cast or pig iron, and is distinguished into two kinds.

1. *Soft metal*; bluish externally, but white, granulated, and spongy when broken. It runs slowly from the furnace, accompanied with blackish or bluish slags, containing a large proportion of metallic grains. This soft metal is the best for refining speedily into tough iron, and is obtained when the quantity of charcoal used is the least that can be employed, and the furnace is not very high.

2. *Hard metal*; white, or grayish white externally, and very brilliant when broken. It runs quickly from the furnace, rises in thin cakes, and the slags are generally whitish. In re-

fining, it forms steel; unless previously exposed to the blast, heated under a fire of small charcoal, but not brought to melt. This metal is obtained when the smelting is performed with more charcoal than is necessary, and the furnace is tall.

These furnaces are esteemed the best for smelting sparry and hæmatitical iron ores, particularly when it is intended to manufacture natural steel, rather than either cast or tough iron.

The greatest part, however, of pig iron, is smelted in high furnaces.

The four figures here given, exhibit the principal vertical and horizontal sections of the high furnace of Elend, in which iron is smelted by means of charcoal.

Fig. 177, is a vertical section, in the direction *a, b*, of fig. 180.

Fig. 178, is another vertical section, in the direction *c, d*, of fig. 180.

Fig. 179, is a horizontal section, taken at the height *i, k*, of fig. 177.

Fig. 180, is a horizontal section, taken at the height *l, m*, of fig. 177.

In these figures, *a*, is the fire room, which is in this instance 28 feet high, and octagonal, but in many furnaces square. *B*, is the mouth or top, by which the furnace is charged, 3½ feet over, surrounded by a brick wall, *c*. *D*, is the internal lining, of very refractory sand-stone. *E*, is the external lining, or chemise, formed of clay mixed with small stones or slags. *F*, is the main mass of the furnace, or mantle; it is solidly built of gray wacke stone, connected by cement, and bound together by iron bars. *G*, is the twyer arch, by which the blast pipes pass to the interior of the furnace. *H*, is the tympan arch, by which the furnace is tapped, and the metal run out. *I*, are thick iron bars; some supporting the two linings of the fire room, and others preventing their bulging at bottom. *K*, are strong bars of tough iron, built in the main mass of the furnace at different heights, with large keys at each end, to prevent the walls from bulging or cracking. *L*, are channels of tiles, made in the masonry, to allow the moisture of the stone to evaporate and disperse. *N*, is the twyer hole. *O*, is the dam-plate, of cast iron, over which the slags run out when the crucible or hearth of the furnace is full. *P*, is a cast-iron plate, serving to support the dam-plate. *Q*, is another cast-iron plate, supporting the roof of the twyer hole. *R*, are the cheeks or sides of the tympan. *U*, are walls, or battlements surrounding the mouth of the furnace. *V*, is the flooring, on which the workmen stand when charging the furnace. *W*, is the bottom of the fire room, on which bottom is constructed the crucible or hearth, on a bed of sand closely packed together. *X*, is a gutter in the floor of the workshop, along which the metal runs when the furnace is tapped. *X*, are two stones, which close the fire room at bottom.

The main mass of this furnace, with its linings, serves for years; but the crucible, which is three feet deep, and two feet wide at bottom, being made of blocks of sand-stone, is gradually dissolved by the iron, so that the fire is seldom kept in for more than forty weeks, and then let out, in order to repair this part. *Z*, is a single block of stone, forming the back of the crucible. 1, 2, 3, are the stones on the twyer side of the crucible. 4, 5, 6, are the stones of the crucible, opposite to the blast hole. 7, are the stones forming the sides of the tympan. 8, are the stones of the fore part of the crucible. 9, is a strong iron bar, called the tympan, which supports the eye, or opening into the crucible. 10, are the stones, forming the dam over which the slags run.

These dam stones occupy the whole breadth at the bottom of the hearth, excepting about six inches; which, when the

Fig. 177

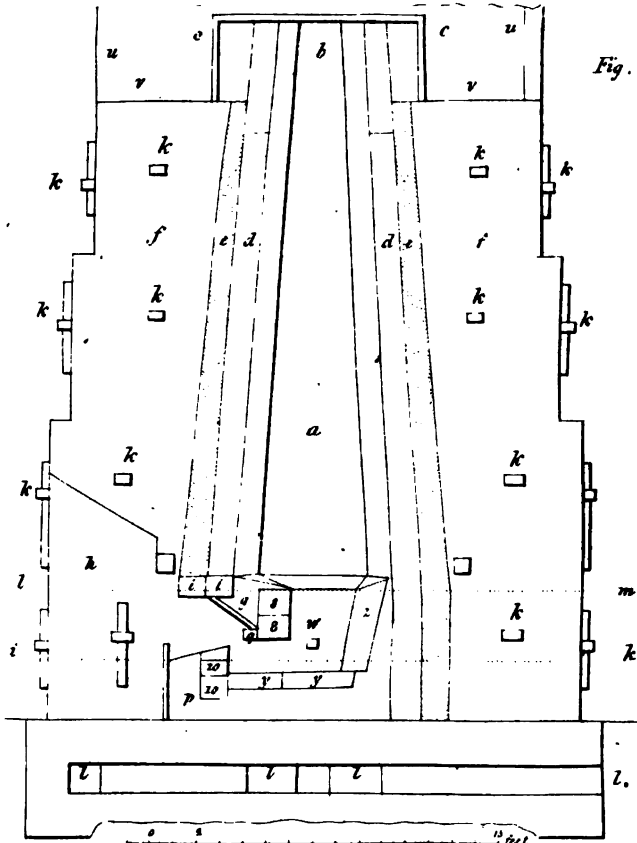
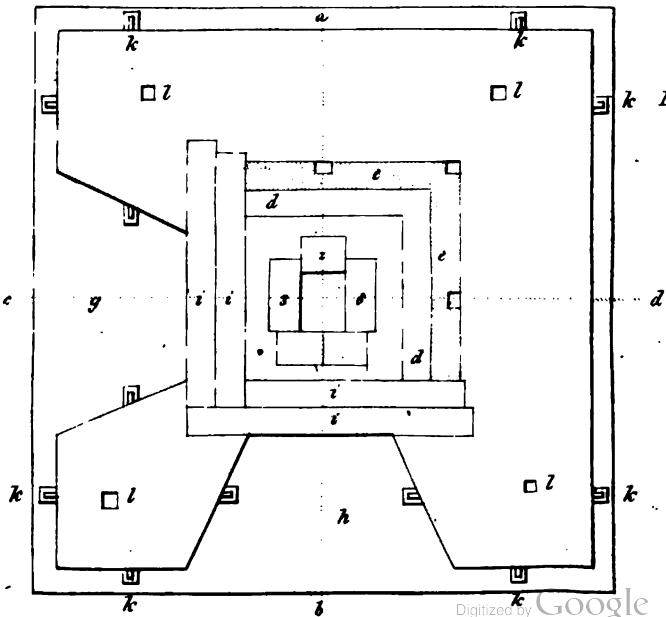
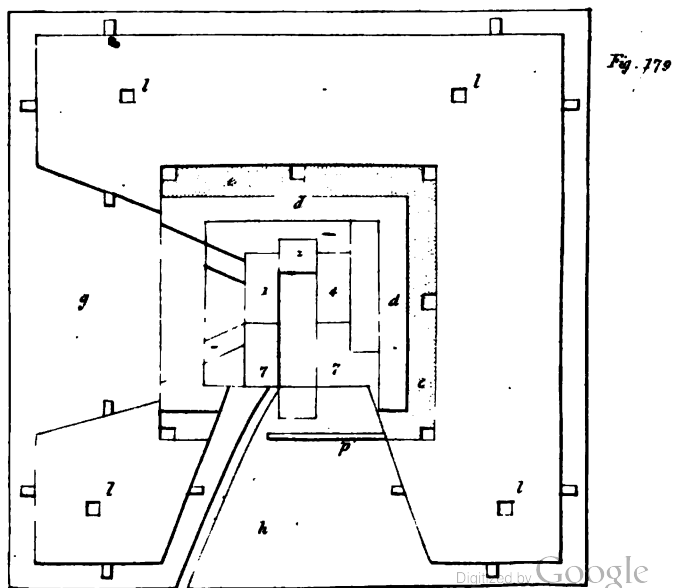
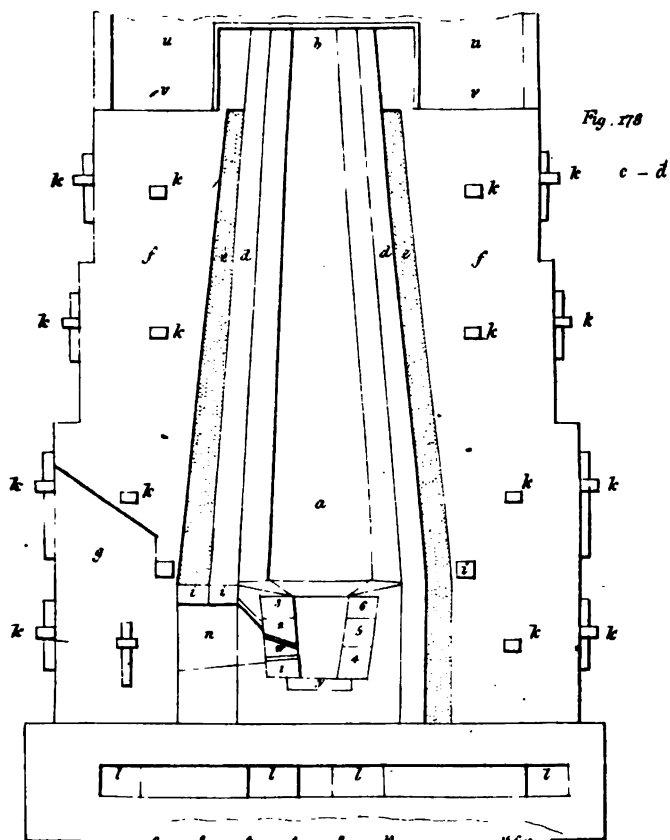


Fig. 180









furnace is at work, is filled every cast with a strong binding sand, which is broken through when the metal is run out. The top of the dam stone, or rather the notch of the dam plate, is from four to eight inches lower than the twyer hole. The space under the tymph plate, for five or six inches down, is also rammed every cast, full of strong loamy earth, and sometimes even with fine clay; this is called the tymph stopping.

11, is the twyer, to receive the blast pipe.

In all these furnaces, the blast pipe is furnished with several nosles, or nose pipes, from two to four inches diameter, which are screwed on, according as the furnace is deemed to require an alteration in the volume, or density of the blast.

12, are the inclined planes, called boshes, forming the top of the crucible, and supporting the charge of ore and charcoal; the fire-room being seven feet wide. In some furnaces of this kind, the crucible is not so much contracted as in this furnace.

The French and German high charcoal iron furnaces, seldom exceed 30 feet in height; the ores yield scarcely one half their weight of metal, and as the blowing machines are usually only wooden bellows, the furnace seldom yields more than 200 or 300 cwt. of cast-iron in a week, at the expense of 1 cwt. seventenths of charcoal for each cwt. of metal.

In Sweden, the furnaces of this kind are usually about 35 feet high; the internal part above the boshes is a very long ellipsoid, whose smallest diameter of 8 feet, is placed horizontally 14 feet above the bottom of the crucible. A furnace of this kind, but only 30 feet high, blown with leather bellows, in which clay iron-stone was mostly smelted, 106 cwt. of iron was produced every 24 hours, or 742 cwt. by the week: 130 pounds of charcoal, were consumed for every 100 pounds of iron produced.

At Newjansk, in Siberia, a furnace of this kind has been built, in which the crucible is 7 feet high, the swelling of the boshes occupy nearly the same height, above which is a truncated cone, 21 feet in height, ending at top in a cylinder of 6 feet high; so that the whole height of the fire-room is 41 feet. The diameter at the bottom of the crucible is 2 feet $\frac{1}{2}$; at the top, 4 feet $\frac{1}{2}$; at the boshes, 13 feet; and at the mouth, 6 feet. The blast hole is 2 feet above the bottom of the crucible, and the blast is given by four cylindrical machines. In this furnace, a mixture of about one-third of hæmatites, with two-thirds of common magnetic iron ore, is usually smelted; and it is said to yield 404 cwt. of iron every 24 hours, or 2826 cwt. by the week; and only 115 pounds of charcoal are consumed in pro-

be high enough blown, or decarburetted, the proportion of coke, &c. is to be gradually reduced, or that of the ore or slags, with a proportional quantity of lime, or other flux, increased, until the metal is of a proper quality for the paddling furnace or stamping fire.

In the smelting of 600 pounds of pig iron, with 180 of slags, 100 to 150 of limestone, and 300 to 400 of coke, there are generally obtained 24 or 25 cwt. of finers' metal, from each ton of pig iron.

This method of smelting may be applied to the manufacture of pig or cast iron, by keeping the surface of the metal in the hearth, protected by a sufficient depth of slag, and by drawing off the metal from below the slag, instead of allowing the last to flow off above. This mode of making pig iron requires a less powerful blast than the common method; and ores of a richer quality may be used in the furnace, than can be reduced with advantage in the usual mode of making pig or cast iron.

Foundry of Pig Iron.

For the purpose of melting cast iron in small quantities, for the purpose of moulding delicate objects, which require the iron to be in a very fluid state, the Berlin foundry uses the following blast furnace; the metal used is obtained in Silesia, and the castings of this foundry are much esteemed for their workmanship.

Fig. 183, represents the external appearance of the furnace, which is an octangular prism, five feet high, three feet and a half wide, and cased entirely with cast iron plates screwed together. Fig. 184, is the vertical section, in the direction *b, d*, in fig. 187. Fig. 185, is a cast iron plate, which forms the bottom of the furnace, and by which the upright plates, *c*, which form the sides of the furnaces, are kept in their places; a slit, *h*, *e*, and the two holes that are near it, render this connexion easy to be established. A somewhat similar plate forms the top of the furnace, and retains the upper ends of the side plates in their places. Fig. 186, is the plan, taken a little above the twyer, *i*, in fig. 185.

In all these figures, *a* is the lining of the furnace, composed of refractory brick work. *B*, a lining of unfusible sand, well packed together. *C*, plates of cast iron, forming the external sheathing of the furnace. *D*, is an eye-hole, which is occasionally opened to let the melted metal run into the moulds. *E*, *f*, is the bottom plate of the furnace, set upon a low mass of brick work. The top plate has a large round hole, through which the furnace is charged with coke and metal. *H*, is a hole made in the bottom plate, above which is made a bed of unfusible sand. *I*, is a cast iron twyer, to receive the nose of the blower cylinders.

The fusion of 30 cwt., of 132 pounds each, or nearly two tons of iron in this furnace, lasts in all nine hours, and consumes 63 cubic feet, or 15 cwt. of good coke. The first three hours are employed in heating the furnace gradually, the blast is then let on, and the furnace charged with metal. One hundred pounds of metal generally produces 93 of very fine cast work, so that 7 pounds of iron are lost.

Fig. 182.

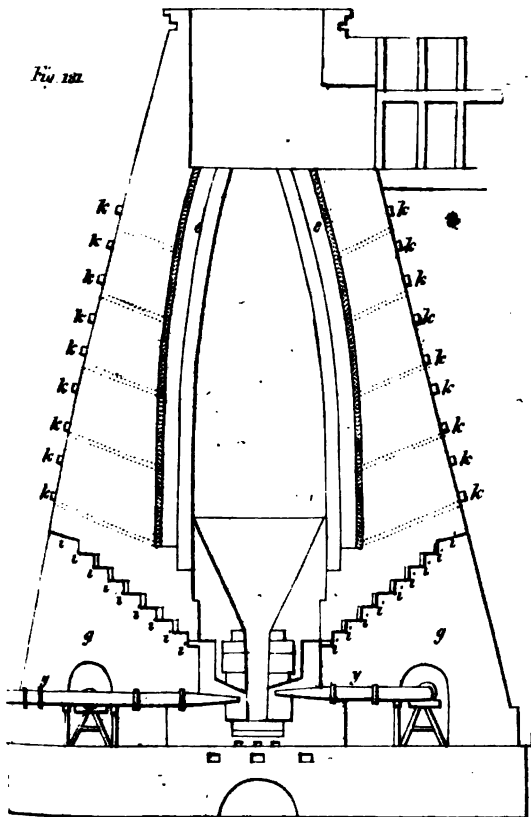


Fig. 183.

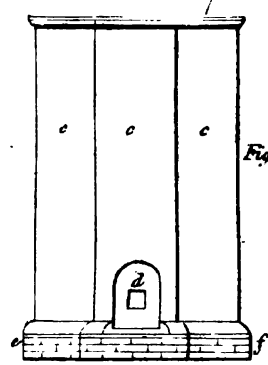


Fig. 184.

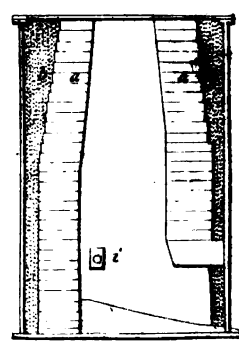


Fig. 182

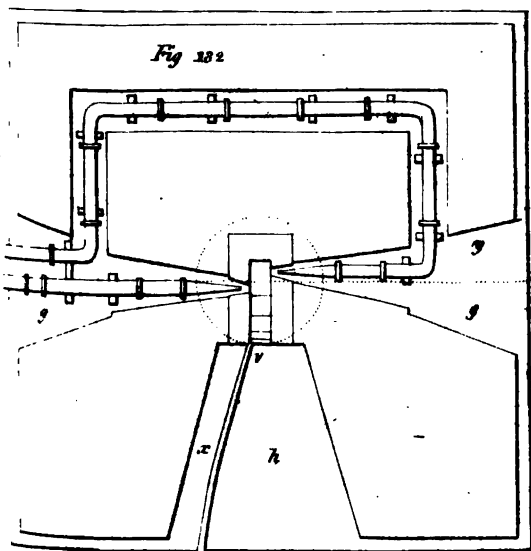


Fig. 185.

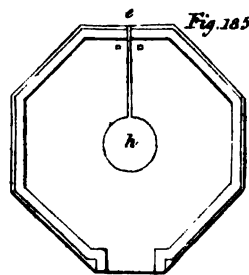
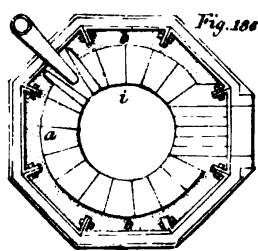


Fig. 186.



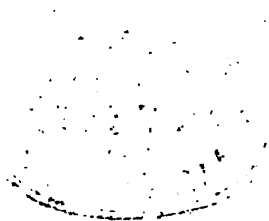




Fig. 187.

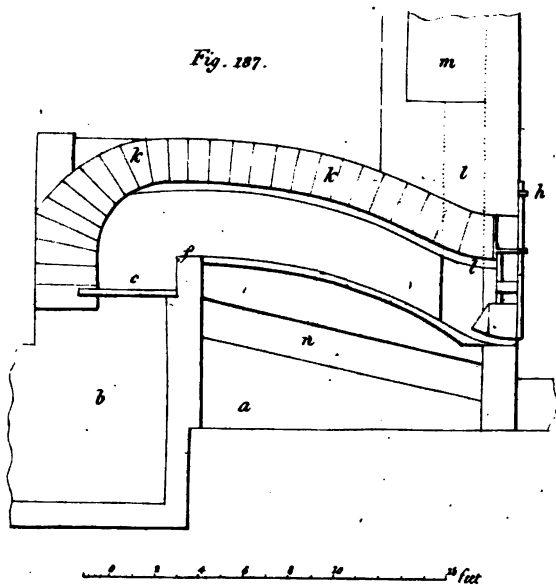
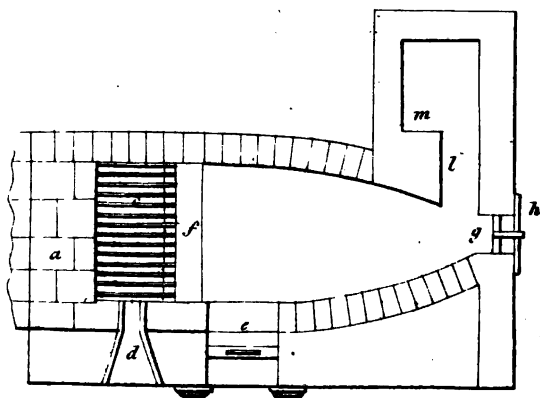


Fig. 188



For smelting cast iron in larger quantities at a time, namely, 50 or 60 cwt. reverberatory furnaces are usually employed.

Fig. 187, represents the vertical section of these reverberatories, in the direction of the line *a, g*; and fig. 188, is the plan of the same, on the level of the bridge. *A*, is the main mass of the furnace. *B*, is the ash-room, which is made very large. *C*, is the grate, formed of iron bars. *D*, is the fire-room door. *E*, is the door into the chamber, by which the furnace is charged with the iron to be smelted. *F*, is the bridge between the fire-room and chamber, over which the flame passes. *G*, is another opening into the chamber, by which the charge when melted may be taken out in ladles; this opening is shut by means of an iron door lined with clay, which is prevented from opening when the furnace is highly charged with iron, by iron bars, *h*, running through staples driven into the furnace. *I*, is the eye of the furnace, usually kept close with a plug, which is withdrawn when the whole melted metal is to be run out at once into the moulds. *K*, is the arched roof of the fire-room and chamber, inclining downwards towards the vent, in order to direct the flame upon the charge in the chamber. *L*, is the vent, which communicates with the chimney, *m*, built separate from the furnace, and carried about 35 feet at least above the level of the vent. *N*, is the gutter, left in the brick work under the bed of the chamber, to hasten the drying of the furnace.

Fifty cwt. of cast iron may be conveniently melted on the bed of this furnace, in three or four hours, by means of 70 cubic feet, or 34 cwt. of raw pit coal, if the weather is cold; but in warm weather more fuel is required. In this melting, each cwt. of iron loses about 10 or 12 pounds of its weight; notwithstanding the bed of the chamber is made of clay mixed with charcoal or coal dust.

A series of experiments, made at the royal foundry at Berlin, have shown that 100 cubic feet of raw pit coal produce the same effect as 475 cubic feet of beech wood.

Cast iron run into sand moulds is soft, and when turned in a lathe, the turnings will be even one-sixth of an inch thick; but if the iron is run into cold thick cast iron ingot moulds, the melted metal is so much chilled that the surface becomes quite hard, and when turned in a lathe, the turnings are not larger than very fine needles.

It is very difficult to cast good hard iron rollers; for if not sufficiently hardened at the surface, and to a proper depth, they will not wear well: and if they are hardened to the very centre, they often crack across the middle, and become useless.

For very small castings of only a few pounds, the blue melting pots made of Stourbridge clay and coke powdered, are used, and the melting performed in a common wind furnace. Some founders use American potash as a flux, and thus produce a metal which has considerable elasticity and toughness; so that it may be used for nails, and even table forks.

The Chinese iron founders use a still smaller apparatus; for De Guignes, in his *Voy. a Peking*, ii. 169, says:—

In China, the foundlers traverse the streets to mend the cast iron pots, and work in the open streets. The crucibles in which they melt iron are an inch in diameter, of refractory clay. One workman receives the melted iron on moistened paper, and conducts it into the cracks and holes, while another spreads and joins it with a humid rag. The furnace itself is four inches broad, and eight long, it contains several crucibles, which are covered with a stone in order to concentrate the heat. The workman's box is six inches broad, sixteen long, and eighteen high. It is divided into two portions, the upper part contains the necessary apparatus; the lower is the bellows, composed of a diaphragm exactly fitting the hollow in the box, and which can be moved by means of a handle formed of two small iron bars. The fore and hind part of the box are furnished with valves, and there are two others which open into a small channel that runs along the outside, and having in the middle of the box a pipe. When the workman draws the piston to him, the valve behind opens, and that in front shuts, so that while the wind is forced into the small channel, the hind part of the bellows is filling with wind. This kind of bellows yields a good blast, and does not fatigue the workman.

Charcoal made tough Iron.

The Catalan forges are the most simple apparatus for obtaining tough iron, even directly, from its ores; they produce excellent iron, and require only a small capital to establish them. On the other hand, they expend a considerably greater proportion of charcoal than the other kinds of furnaces; each furnace supplies only a small quantity of iron weekly, and this iron is either tough iron or steel, not the common cast iron as furnished by the flowing and high furnaces.

The section of the Catalan forge is represented in fig. 189, and its plan in fig. 190; the cavity, *c*, is generally sixteen inches square, and about two feet deep. The sides, *r*, *k*, *v*, of the cavity, for about eighteen inches deep, are lined with cast iron plates, and the remainder is filled up with charcoal reduced to powder. One of the sides, *k*, is pierced with an eye-hole, which is occasionally opened to let the slags run out.

The ores usually smelted in these furnaces, are the different oxides of iron, called marsh ore, bog ore, ochres, both yellow and red, hæmatites, sparry iron ore; none of which require previous roasting, as not being united with sulphur or arsenic. The ore reduced to small pieces is mixed with charcoal, and the furnace gradually charged with it. As the metal is reduced, it descends into the lower part of the furnace, where it is preserved from calcination, by a bed of charcoal dust, *p*. As the bottom of the furnace gets nearly full of iron, the slags flow out at the eye-hole; and when the metal appears at this hole, the mass, which is of a paste-like consistence, is withdrawn and put under the hammer, and forged at once. Some ores even yield steel in this process.

The metallic cakes, called loupes, weigh from 2 to 4 cwt., and three or four of them may be obtained in a day and night. In smelting the hæmatitical ores, 7 cwt. of charcoal are consumed

in making one of iron; but only 3 cwt. in smelting the sparry iron ore; and a single Catalan forge will furnish 90 cwt. of iron by the week from this ore.

It is, however, more usual to obtain tough iron from cast iron and finers' metal, by various processes of refining, by means of charcoal.

The tough iron of the Continent is usually obtained from pig iron by several successive meltings of the iron in the basin or crucible of a forge hearth, lined with thick plates of cast iron.

To refine pig iron in the German method, called *klump frischen*, the forge hearth is filled with burning charcoal, and the pigs of iron being placed opposite the blast, about six or eight inches from the nose of the pipe, the iron melts, and falls to the bottom of the basin; the workman keeps pushing on the pigs, until a sufficient quantity is melted. The slags that are formed on the surface of the iron, are run off by an opening for that purpose, and the melted metal stirred with an iron bar, which coagulates into a soft mass, which is first turned over to expose the under surface to the fire, and then brought up opposite to the blast, and again smelted, and the same treatment repeated until the mass is thoroughly malleable. The mass of iron generally weighs 2 cwt. One hundred parts of gray pig iron loses about 26 in this operation; and each 100 pounds of tough iron, occasions the consumption of 149 pounds of charcoal of resinous wood. The operation generally lasts five hours, and as soon as it is finished the bellows are stopped, the mass is taken from the fire and forged by a hammer of about 9 cwt., to drive out the slags and oxide still remaining in it. The mass is then divided into four or six pieces, and these are heated and drawn out into bars, on the same forge hearth, while fresh pigs of iron are being melted to form another mass of tough iron.

The German method of *durchbrech frischen*, is similar to the former; but instead of taking out the whole mass of metal to remelt it, only a portion at a time is presented to the blast, in order that the air may have a greater effect in purifying the metal. This method is not so much used as the former.

In the *koch frischen*, *kalt frischen*, or *Rheinische frischen*, as soon as the pig iron is melted, the blast is directed to the bottom of the basin of the forge hearth, the metal is then uncovered and stirred with a rod; it first boils up, and the bellows being stopped, it coagulates into a mass, upon which a little water is flung to cool it. The metal is then taken out of the basin, and again melted before the blast, until it is fit to be forged.

In the *anlauf frischen*, as soon as the metallic mass is re-

melted, a thick rod of cold iron is plunged into it, to which some of the metal adheres; this portion is carried to the hammer and forged. The same manœuvre is repeated with another cold rod, and after thus repeatedly subtracting a portion of the melted iron in this manner, the remainder is treated in a single lump as usual.

The Bergamasque mode of refining pig iron into tough iron is, as soon as it is smelted to run it out upon the floor, which is covered with the finery cinders of former operations, and sprinkle it with water. The plates thus formed of metal and cinder are broken and remelted before the blast, and run into smaller plates, which are again remelted separately in the same fire, and carried to the hammer.

In Styria, the hard pig iron run into plates, is roasted by being heated under a fire of small charcoal for some time to burn out the superfluous carbonaceous matter, after which, the plates are melted upon a forge hearth, the basin of which is lined with moist charcoal in powder. The workman merely stirs the melted metal, and does not raise it up to the blast; so that it appears to refine itself gradually. The mass, when it grows solid, is carried to the hammer, and thus excellent iron is produced.

In the French mode, called *mazéage*, the pig iron is first melted on the forge hearth, and run upon the moist floor of the workshop, to reduce it into thin plates usually of a white and spongy grain. If the grain is gray, the plates are made into conical heaps and roasted. After these preliminary operations, the metal is again melted on the forge hearth, and the mass carried to the hammer.

The Walloon method of refining white cast iron, is merely to melt it under a little slag, and stir it to disengage the carbonic acid gas that is formed: it speedily refines of itself, and fixes into a lump that is capable of being forged.

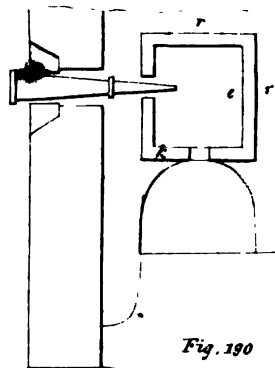
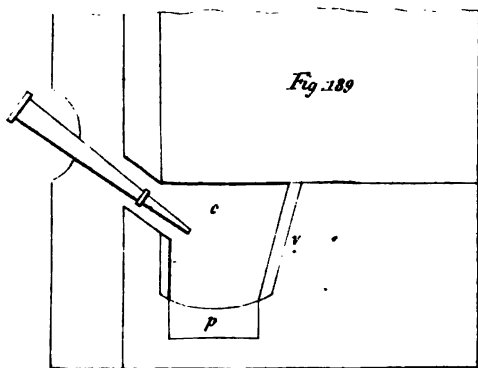
The Walloon method of refining dark cast iron is to melt it and expose it repeatedly in portions to the blast of the bellows, to burn out the carbonaceous matter, and thus at length obtain tough iron.

As one part of iron is calculated to consume five parts of charcoal in its making, it will follow that two or three parts of potassium may be combined with 100 of iron.

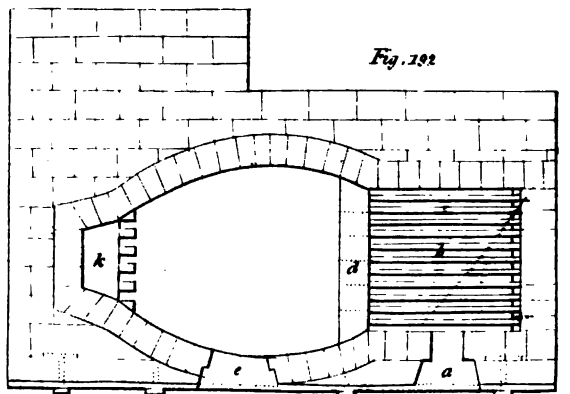
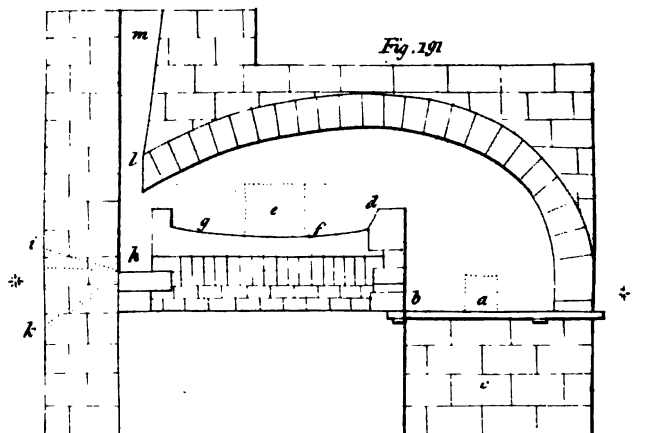
This small quantity of the new metal that can thus be combined with the iron during the different operations that it undergoes, might be supposed to have no effect upon the iron, if we did not know that an equally minute proportion of phosphorus renders iron brittle in the cold, and an equally small quantity of sulphur or copper, renders iron brittle when red hot.

From trials, it was concluded that iron may be united with potassium in two different proportions. In the one, in which the potassium is in the smallest proportion, the iron has a dead white colour, like that of platinum; in the other,





0 1 2 3 4 feet



0 1 2 3 4 feet

in which the potassium is in the greatest proportion; the iron has a brown colour, mixed with white points.

The white potassinated iron works very easily either hot or cold, is more malleable than iron, and acquires hardness by tempering, but without becoming brittle like steel. Of course, it is most probable that the small quantities of potassium that combine with the iron, when smelted and forged by charcoal, only help to improve it; and is in fact the cause of the superior quality of the Swedish iron, which is all made with charcoal.

The iron that has combined with the greatest proportion of potassium takes a more or less deep brown colour, mixed with white points. In this state, the parts have but little cohesion; it is cold, short, and probably brittle when red hot.

Coke-made tough Iron.

In the English method of making tough iron, the pig iron is first reduced into finery metal on a finery hearth, called also a refining furnace, or run out furnace. This forge being filled with lighted coke, the pig iron cast in pigs of about half a cwt. each, is placed on the coke; and as it melts it drops through the coke into the basin, where it remains exposed to the action of the blast, for about two hours, or even twice as long, but protected from the contact of the fuel by the slags or cinder on its surface. The basin is then tapped at the lower part, and runs out into the mould. The finery metal has a very white grain, similar to steel.

Fig. 191, represents the plan of the ball furnace, puddling furnace, or reverberatory furnace, used in England to convert finery metal into tough iron, by means of raw stone coal. Fig. 192, is the vertical section, in the direction, *A, A*, is the fire door. *B*, is the grate, which is about three feet each way. *C*, is the ash room. *D*, is the bridge between the fire and the basin. *E*, is the opening, by which the furnace is charged. This opening is closed during the process, by means of a cast-iron door, lined with brick work, suspended at the end of a lever, as will be shown in the Hartz cupola for cupelling silver. This door has in the lower part a small opening, by which the workman introduces his tools, and which he afterwards shuts by means of a small door, in which is an opening or spy hole, about $\frac{1}{2}$ inch in diameter, to inspect the state of the work. *F*, is the bed of the furnace, $4\frac{1}{2}$ feet long, and 4 feet wide, made of very unfusible sand, which is heaped upon a flooring of bricks. *G*, is the edge of the sand bed, with several gutters to allow the slags to run off. *H*, is the basin, into which the slags are allowed to run. *I, k*, is the opening by which the slags are run out of the furnace. *L, m*, is the chimney, which rises 40 or even 50 feet above the top of the furnace. The whole of the furnace and chimney is firmly bound together by strong bars and cramp irons.

In order to obtain tough iron from the finery metal, the reverberatory, puddling, or ball furnace, is first brought into heat with raw coal, and then there are placed upon the bed 300 pounds of the finery metal, the opening by which the bed was charged is closed with its door, and the little wicket also closed. In about half an hour, the metal is usually melted, and then the workman introduces by the wicket an iron rod, and stirs the melted metal to expose all parts of it to the flame;

during which time the metal swells, and throws out sheaves of brilliant sparks. As the iron becomes pure, it fixes in grains, which are united together by the workmen, and formed into small balls. The slag or cinder that swims on the metal, is run out as often as the basin is full. The metal thus refined, is brought together into several small balls, which are placed round the bed of the furnace, where they remain exposed to the action of the flame until they are taken out one by one, to be submitted to the stamping hammer or rollers. The whole operation generally lasts an hour and a quarter. As soon as the last ball is taken out, the furnace is charged afresh.

The rollers which are mostly used in England for the sake of despatch, instead of the hammer to squeeze out the remaining slag from the iron, and convert it into bars, are grooved with channels of different sizes. In the first pair of rollers, the grooves are four in number, and the lump of iron from the ball furnace is passed through them in succession. After this, the lumps or blooms are heated in another reverberatory furnace, with a flat hearth, and passed through another pair of rollers, grooved with six channels of different sizes, and are then considered as reduced to saleable iron. Hammered bar iron is, however, esteemed of superior quality to rolled iron.

In this mode of refining, it requires 4 cwt. of pig or cast iron to obtain 3 cwt. of bar iron, and each pound of bar iron causes the consumption of 6 pounds of raw coal for its refining; to which, if there be added the quantity of coal or coke required for smelting the pig iron, it will appear that each pound of coal made iron, has consumed 10 pounds of coal in its manufacture.

Coke-made iron, is used for the coarser purposes of the arts, where great strength in a small bulk of the material is not required: its price is generally $\frac{2}{3}$ that of charcoal-made iron.

Soldering for Iron.

When the filings of soft cast iron are melted in a crucible with borax, which has been previously calcined in order to get rid of the water it contains, a hard, shining, black pitch-like soldering substance is obtained, being glass of borax coloured black with iron.

Sal ammoniac having been applied to the internal joining, or between the overlapped edges of thin sheet iron, some of this black solder being powdered is to be laid along a short portion of the joint, and as soon as it is melted over a clear forge fire, the soldered part is to be placed on the beak of an anvil, and beaten with a light hammer and quick hand, as long as the heat permits. More of the powder is then to be laid

upon the adjoining part of the joining, until the whole of the seam is soldered.

Another method, which has been published for this purpose, is to melt five ounces of borax in an earthen crucible, and when melted, to add half an ounce of sal ammoniac, and pour the melted matter upon an iron plate. When cold, it will appear like a glass, and is to be powdered and mixed with an equal quantity of unslaked lime.

The iron or steel being heated to a red heat, a little of the above powder is to be sprinkled on the surface, where it will melt like sealing wax. The iron or steel is then to be again heated, but considerably below the ordinary welding heat, then brought to the anvil, and hammered until the surfaces are perfectly united.

Natural Steel, or German Steel.

This steel is the most impure, unequal, and variable of the three kinds of steel, but it is considerably cheaper; it has also the property of being easily welded either to iron or to itself, and some other qualities which render it frequently preferable to the other two kinds of steel.

Its grain is unequally granular, sometimes even fibrous; its colour, usually blue; it is easily forged; it requires a strong heat to temper it, and it then acquires only a middling hardness; when forged repeatedly, it does not pass into iron so easily as the other kinds.

There are subdivisions of this steel, that are procured from cast iron, and that obtained at once from the ore.

The steel yielded by cast iron, manufactured in the refining houses, is known by the general name of *furnace steel*; and that which has only been once treated in the refining furnace, is particularly called *rough steel*, and is frequently very unequally converted into steel. Both these varieties are drawn into bars, then hardened, and broke into pieces.

Some manufacturers examine these pieces, sort them according to the appearance of their grain and fibres, and uniting several bars, either of the same or different qualities, into a bundle, they forge them, and draw the whole out; in this manner they procure the steel called twice marked. The bars of this steel are sometimes folded together several times, and again drawn out into bars, called thrice marked steel; this steel is highly elastic, more perfect, and of greater price than the former.

The best cast iron for the purpose of making natural steel, is that obtained from hæmatites, or from sparry iron ore; if it con-

tains manganese, this is thought to be of advantage. It should be of a gray colour; white cast iron does not yield steel, unless its charge of carbon is increased, either by stirring the melted metal with a long pole, and keeping it melted a long time, that it may absorb charcoal from the lining of the furnace, or by melting it with dark-coloured iron. Black cast iron yields a bad brittle steel, unless the excess of carbon that it contains is either burnt away, or is mixed with finery cinder. The cast iron to be converted into steel, is then melted in blast furnaces, and treated nearly the same as if it were to be refined into bar iron, only the blast is weaker, the twyer, instead of being directed so as to throw the wind upon the surface of the melted metal, is placed nearly horizontal, the melted metal is kept covered with slag, and is not disturbed by stirring: when the iron is judged to be sufficiently refined, and is grown solid, it is withdrawn from the furnace and forged. After this natural steel is made, there is almost always taken out of the refining furnace, towards the end of the operation, one or more pigs of iron, which is rather hard, and used for implements of husbandry.

Natural steel is sometimes made at once from the above-mentioned ores in small blast furnaces; which, from their being much used in Catalonia, in Spain, are called Catalan forges. The steel produced in them is a good steel for ploughs, and similar machines; that with three marks is excellent for springs and sword cutlery.

That is the best natural steel which is the densest, becomes the hardest when tempered, and is not brittle. Its grain should be very fine and equal, and it should be capable of being forged and welded without breaking or splitting; lastly, it should support the action of the forge well, without changing its nature.

Natural steel has, in general, the defect of being strawy, or containing parts which are not steel, but merely cast iron. Sometimes it is cindery, its surface being covered with small holes; but this seems merely accidental, and owing to its being treated with too strong a heat. It is in order to remedy these defects that this steel is bundled together and forged.

The most esteemed natural steel made in Germany, is that of Styria: it is usually sold in chests or barrels, two and a half or three feet long. Its grain is even, close, and fine, but when polished, it shows fibres, cinders, and threads, from which even this steel is not entirely free. Sometimes, when broke, it has in the middle of the fracture a spot, yellow, orange, or blue, which is called the rose, and the bars in which it appears are called *rose steel*. It has been thought, that this rose was a mark of goodness, and the manufacturers of steel in other places have

attempted to imitate it; but in fact, this rose is a sign of defect, and is only found at the place where the bar breaks with the greatest ease: indeed, it appears to arise from a straw which is formed at the time of tempering the steel. Files, and the best kinds of tools, are usually made of this steel in Germany; the proper colour for hardening it, is a cherry red heat.

The next esteemed steel, is that called distinctively *German steel*, or *Pont stuff*. It is not so good as the former; is sold either in bars, 10 or 12 feet long, or in barrels about three feet long; it is marked with an anchor, or seven stars in a circle. This is the most used.

There is also a steel in Germany, called *Cologne steel*, forged in bars 3 inches $\cdot 5$ long, 1 inch $\cdot 25$ wide, and 0 inch $\cdot 75$ thick; another called *Soligen steel*, *Hungarian steel*, marked with an oak leaf, and sold in bundles of four or six bars, fastened together with iron bands: the bars are of different sizes, but one inch $\cdot 25$ square.

The French have also manufactured natural steel for a long time, but it is only lately that they have begun to improve their quality, and to attempt to rival the German steel. The best French steel works are those of Rives, in the department of the Isere, which is used for large cutlery, and might perhaps be used for the finest. The steel of Berardiere is used for all kinds of springs, as also for cuirasses, which are usually made of iron; but those of this steel, well forged, offer four times the resistance, although equally light, and not dearer. The natural steel of La Hutte, department of the Vosges, is esteemed excellent for saws. Good natural steel is also manufactured at Neronville, in the department of the Nièvre, and sold in pieces six to seven inches, five long, and an inch and a half square, marked with an N.

Fig. 193, represents the plan of a forge hearth used at Koenigs-huette, to obtain natural steel from pig iron. Fig. 194, is a vertical section, in the line, *t, u*; and fig. 195, another vertical section, in the line, *y, z*. This forge hearth is built under a chimney or hood, as usual. *A*, is a slab of refractory sand-stone, forming the bottom of the basin or hearth. *B*, is a space filled with moistened small pieces of charcoal, and under which is a layer of rammed clay, *x*. *D*, is a plate of cast iron, forming one side of the hearth. *F*, is another plate of cast iron, forming that side that is opposite the blast hole. *G*, is the cast iron plate, of the side towards the blast hole. The basin on the back side, *d*, is only five inches and a half deep, but on the front, and the side, *f*, it is eighteen inches deep; but the back side, *d*, is raised by means of a bank of dry charcoal, to the same height as *f*. *I*, is an opening, by which the slags are run out during the work, and by which the cake of steel is raised up when it is finished. *K*, *l*, *m*, *n*, are lumps of cast iron, that are used to confine the fire on the front where the workman stands. *O*, is the floor of the workshop. *P*, is a copper twyer, which is placed at four inches and a half from the bottom, *a*, inclines five degrees towards it, and is advanced four inches into the fire; the opening being one inch and a half long, and an inch high. *Q*, are the noses of two bellows, of an inch in diameter each.

Natural, or German steel, does not take a very excellent polish, or take a very hard temper, nor is perfectly alike in every part, some parts being, in fact, only iron beginning to be converted into steel; but it may be forged and welded together very easily.

The steel brought from Bombay, by the name of wootz, or Indian steel, is also a kind of natural steel; for it is obtained by smelting the ore in melting pots, several of which are placed in the same blast furnace. This kind of steel is remarkable for the beautiful veiny appearance instruments made of it exhibit, when polished, as though they were composed of iron and steel welded together, and repeatedly twisted. This veiny appearance has been long known to the sword cutlers, and having been first seen in the sabres made at Damascus, acquired the name of damask, and even communicated it to a kind of woollen cloth, exhibiting the same veins. The damask of wootz, cannot be the effect of the mechanical mixture of iron and steel, since it retains the appearance even after being melted.

M. Breant is of opinion, that Indian or Damascus steel, is a steel more highly charged with carbonaceous matter than the European, and in which, by means of slow cooling, a separation takes place; and two distinct crystallizations, namely, of pure steel, and carbonized steel, takes place. Pure steel does not crystallize, and although when mixed with iron, the damasking or *moirée* takes place, it is white and very slight. It is only when the carbon is in greater quantity than in steel, so that a part of the mass is in the state of cast iron, that the damask is produced, when the steel is slowly cooled, and then plunged into acidulated water, as this acting upon the steel, and rendering it black, renders its crystallization visible.

Very dark gray cast iron, reduced to grains, melted with an equal weight of the same previously calcined, produced excellent Damascus steel for swords. Damascus steel was also obtained by melting one hundred parts of soft iron, with two of lamp black.

Steel also becomes damasked, by being melted with a very small proportion of silver, chrome, and other metals, as described by M. Faraday.

Blistered Steel.

The cementation of iron, converts it into blister steel.

The furnaces used at Sheffield for making steel are, according to Mr. Collier, conical buildings; about the middle are two troughs of brick or fire-stone, which will hold about four tons of bar iron. At the bottom is a long grate for the fire.



Fig. 194

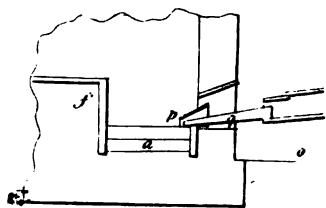


Fig. 193

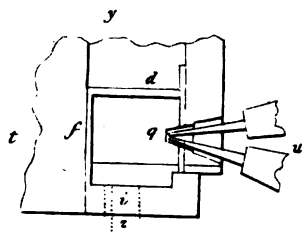


Fig. 195

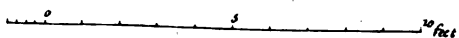
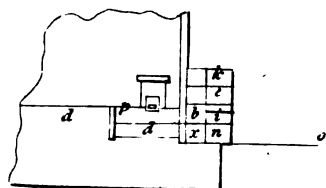


Fig. 197

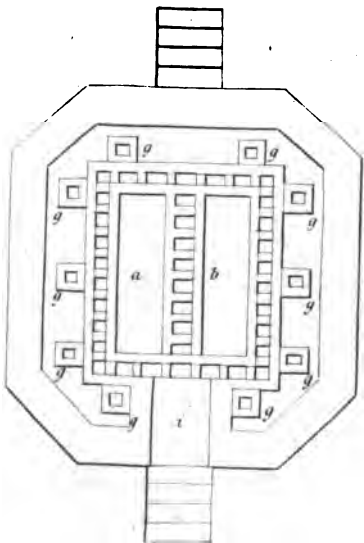
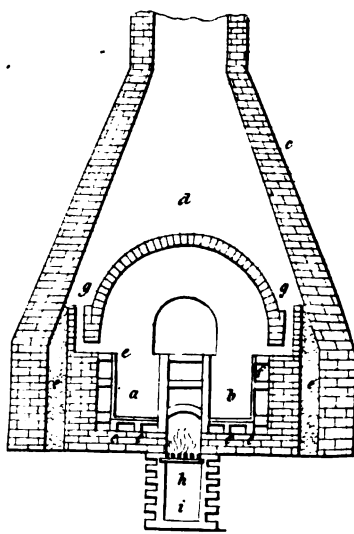


Fig. 198



A vertical section, and horizontal plan of the converting furnace, is shown in figs. 196 and 197.

C, is the external cone, built in a substantial manner of stone or brick-work. Its height from the ground should not be less than 40 or 50 feet; and to procure a still stronger heat, a cylindric chimney, of several feet in length, is most generally built on the top of the cone. The lower part of the cone, which may be made of any dimensions, is built either square or octangular. The sides are carried up until they meet the cone, giving the furnace the appearance of a cone cut to a square or octangular prism at its base, and exhibiting the parabola, where every side intersects the cone.

Inside the conical building is a smaller furnace, called the vault, built of fire brick or stone, which will withstand the action of the most intense heat. *D*, is the dome of the vault, and *e*, are its upright sides; the space between which, and the wall of the external building, is filled with sand and rubbish. *A*, *b*, represent the two pots that contain the iron to be converted into steel. The space between them is about one foot in width, and the fire grate is directly beneath it. The pots are supported by a number of detached courses of fire-brick, as shown at *e*, *e*, in fig. 312, which have spaces between them, called flues, to conduct the flame under the pots. In the same manner, the sides of the pots are supported from the vertical walls of the vault, and from each other, by a few detached stones, *f*, placed so that they may intercept as little as possible of the heat from the contents of the pots. The adjacent sides of the pot are supported from one another by small pieces of stone work, which are also perforated to give passage to the flame. The bottoms of the pots are about six inches thick; the sides nearest together are about five inches thick; and the other parts of the pot about three inches.

The vault has ten flues, or short chimneys, *g*, rising from it three on each side, to carry off the smoke into the great cone, shown in fig. 313, communicating with each side, and two at each end. In the front of the furnace, openings are made, which form the door, at which a man enters the vault to put in or take out the iron; but when the furnace is lighted, these doors are closed by fire bricks luted with fire clay. Each pot has also small openings in its end, through which the bars can be drawn without disturbing the process, to examine the process of the conversion from time to time. These are called the tap-holes; they should be placed in the middle of the pots, that a fair and equable judgment may be formed from their result, of the rest of its contents.

H, is the fire grate, formed of bars laid over the ash-pit, *f*. This ash-pit should have steps down to it, that the attendant to the furnace may get down to examine by the light, whether the fire upon the whole length of the grate be equally fierce; and if any part appear dull, he uses a long iron hook to thrust up between the bars, and open a passage for the air. The fire place is open at both ends, and has no doors. The fire grate is laid nearly on a level with the floor of the warehouse, before the furnace, and the fire door is stopped with a heap of coals piled up before it.

The fire stones composing all those parts of the furnace which are exposed to the action of the heat, are cemented with well tempered fire clay, mixed up with thin water. The fire clay which answers best for this purpose, is the Stourbridge, in Staffordshire; but very good fire clay for the purpose, is procured from Birkin-lane, near Chesterfield.

A layer of charcoal dust is put upon the bottom of the trough, upon that a layer of bar iron, and so on alternately, until the trough is full. It is then covered over with clay, to keep out the air; which, if admitted, would effectually prevent the cementation. The fire is continued until the conversion is complete, which generally happens in about eight or ten days. The workmen draw out, through the opening in the side, a bar occasionally, to see how far the change has proceeded. This they determine by the blisters upon the surface of the bars. If the change be complete, the fire is extinguished, and the steel is left to cool for about eight days more, when the process for making blistered steel is finished.

For small wares, the bars are drawn under the tilt hammer, to about half an inch broad, and three-sixteenths of an inch thick.

The best Swedish iron for making blistered steel, is that of Oregrund and Dannemora, and are distinguished by the marks, hoop L, PL, double star, and double bullet.

The steel, which in cementation becomes covered with large blisters, is of a hard quality, and is used for files, razors, and some other implements; and that which is covered only with small blisters, is mild, and therefore proper for saws, sword blades, springs, and similar articles.

The iron gains by being converted into mild blistered steel, four ounces in a cwt., and into hard steel, 12 ounces in a cwt. If the cementation is continued farther, pig iron is formed.

In some manufactories, the cement is composed of four pounds each of charcoal dust, of wood soot, and of wood ashes, with three pounds of salt.

Blistered steel takes a better polish, and a harder temper,

than natural or German Steel; but it is neither so much alike in every part, nor is it so easily forged or welded.

An imitation of German steel is made by breaking the bars of blistered steel into small pieces, and then putting a number of them into a furnace; after which, they are welded together, and drawn to about eighteen inches long; then doubled, and welded again; and finally drawn to the size and shape required for use. This is also called *shear steel*, and is superior in quality to the common tilted steel.

Cast Steel.

Blister steel of the proper quality, either hard or mild, is changed into cast steel by being broken into small pieces, put into a black melting pot, and covered with a mixture of quick lime and powdered green bottle glass, in order to keep the air from acting on the steel while being melted; but some manufacturers think it is better merely to cover the pot, which is placed in a powerful melting furnace, and kept there for six or seven hours. The steel is then cast into ingots.

This steel is perfectly alike throughout its whole substance, and takes a beautiful polish; but it is extremely difficult to forge or to weld, either with itself, or with iron.

To forge it, the ingot of cast steel must be first heated only to a warm heat, and then slowly hammered until it is rendered compact; after which, it may be hammered quicker. The cast steel must never be heated beyond the least heat necessary to forge it, for the slightest excess will cause it to fly like sand from under the hammer.

Sir. F. Frankland communicated a process, in the Transactions of the Royal Society, for welding cast steel and malleable iron together, which he says is done by giving the iron a malleable, and the steel a white heat; but, from the experiments which have been made, it appears that it is only soft cast steel, little better than common steel, that will weld to iron. Pure steel will not; for at the heat described by Sir F. Frankland, the best cast steel either melts, or will not bear the hammer.

M. Molard has observed, that when blades of cast steel are properly tempered, and then cemented in iron filings in order to reduce their surface to the state of iron, that they acquire the property of cutting iron itself, without losing their edges.

Steel is tempered by again subjecting it to the action of the fire. The instrument to be tempered, may be supposed to be a razor made of cast steel. First, rub it upon a grit stone until it is bright; then put the back upon the fire, and in a short time the edge will become of a light straw colour, whilst the back is blue. The straw colour denotes a proper temper, either for

a razor, graver, or pen-knife. Spring knives require a dark brown; scissors, a light brown, or straw colour; forks, or table knives, a blue. The blue colour marks the proper temper for swords, watch springs, or any thing requiring elasticity. The blades for pen-knives are covered over with oil, before they are exposed to the fire to temper.

Fine cutlery is now mostly tempered by immersion in hot oil, whose temperature is ascertained by a thermometer: and some late experiments have shown, that for certain uses, steel is sufficiently tempered long before it is heated, so as to produce any change of colour, even by a heat only equal to that of boiling water.

Case-hardened Iron.

The surface of instruments made of iron, is frequently converted into steel, in order that they may take a good polish and edge.

This case-hardening, as it is called, is effected by heating them in a cinder or charcoal fire; but if the first be used, a quantity of old leather, or bones, must be burnt in the fire, to supply the metal with carbon. The fire must be urged by a pair of bellows, to a sufficient degree of heat; and the whole operation is usually completed in an hour.

The process for case-hardening iron, is in fact the same as for converting iron into steel, but not continued so long, as the surface only of the articles is to be impregnated with carbon.

Some attempts have been made to give cast iron, by case-hardening, the texture and ductility of steel, but they have not been very successful. Table-knives, and pen-knife blades, have been made of it, and when ground, have had a pretty good appearance, but the edges are not firm, and they soon lose their polish. Common table-knives are frequently made of this metal.

Enamelled Iron Vessels.

It has been generally supposed that of all the metals, iron was the least proper for the purpose of being coated with any kind of glass or enamel. This is, indeed, so far true, that iron does not well bear the common practice of enamellers, namely to be put into the fire and taken out again several times; because the scales which fly from iron, when it is in a hot fire, detach and carry off the enamel.

1. Mr. Rinman reduced into very fine powder, and ground together, nine parts of red lead, six parts of flint glass, two parts of purified pearl-ash, two parts of purified saltpetre, and one part of borax. This mixture was put into a large crucible,

which it only half filled, and being melted a clear and compact glass was obtained. He then covered an iron vessel, on both sides, with this glass, ground with water, and heated it by degrees, under a muffle, in a furnace. The enamel melted very readily in the space of half a minute, and with a very brilliant appearance, and the vessel was found to be entirely coated with a beautiful black colour.

2. He melted together a mixture of twelve parts of flint glass, eighteen parts of red lead, four parts of pearl-ash, four parts of saltpetre, two parts of borax, three parts oxide of tin, prepared by calcination with common salt, and one-eighth of a part of calx of cobalt. A glass of a light blue colour was obtained; which, having been ground with water, and spread upon small iron basins, or tea-cups, produced by means of a brisk fire in a muffle furnace, an enamel which was smooth, even, and of a pearl colour.

He made many trials with the fore-mentioned ingredients, in different proportions, and without the addition of oxide of tin; but none of these experiments succeeded better than that just described.

Black Varnished Iron.

Iron is covered with a shining black varnish by merely being heated red hot, and rubbed over with a ram's horn.

Tin Plate.

Charcoal made tough iron of the finest quality, called tin plate iron, is used for making tin plate, and being rolled and cut to the usual sizes, from 12 inches $\frac{3}{4}$ to 16 $\frac{1}{2}$ long, and 9 inches $\frac{1}{4}$ broad to 12 $\frac{1}{4}$, are first scaled by being bent in the middle, steeped for four or five minutes in a mixture of four pounds of muriatic acid, with three gallons of water, and then heated red hot in a reverberatory furnace, until the heat takes off the scale. The plates are then straightened again, and beaten smooth, when their surface will be found moirée, or mottled, with blue and white, like marbled paper; after which, they are rolled between cold rollers.

The plates are then left for 10 or 12 hours in water, in which bran has been steeped for nine or ten days, and thus turned sour; from which they are removed to a leaden cistern, containing water soured by oil of vitriol, where they are agitated for about an hour, or until they become perfectly bright and free from any black spots. After which, they are put into pure water, and scoured in it with tow and sand; and here they are left until wanted for tinning.

The tin used, is a mixture of equal weights of grain and block tin, which is kept melted in an iron pot, along with some common grease, which is preferred to pure fresh tallow, in the utmost heat that can be used without setting the grease on fire.

The plates are first kept for an hour or more in a pot of melted grease, and then transferred to the tin pot, where they remain an hour and a half, or even longer, then taken out and drained on an iron grating.

The superfluous tin which adheres to the plates, is washed off, by dipping them into a wash pot, which usually contains three blocks, or about half a ton of grain tin, in a melted state, divided into two parts, by a partition which does not go down to the bottom. The plate being dipped, is raised up, and one of its sides brushed; it is then turned, and its other side brushed, and immediately dipped a third time in the other part of the pot. As the tin washed off the plates, deteriorates the quality of the grain tin in the wash-pot, as soon as about 15,000 plates have been washed, that is to say, every second or third day, about three cwt. of the tin is ladled out, and its place supplied with a fresh block of grain tin.

From the wash-pot, the plates are removed to a pot of melted tallow or lard, the temperature of which must be varied according to the thickness of the plates. Here they are placed upright and kept separate, by means of pins in the sides of the pot, which holds five of the plates. Those which have been in this pot the longest, are removed regularly to an iron grating to drain and cool.

Finally, the wire, or list of tin that remains at the bottom of each plate when cold, is removed by dipping this lower edge into a pot of melted tin; and after it is taken out, it is struck a smart blow with a thin stick, which disengages this list. The plates are then cleansed from the tallow by means of bran, and packed for sale.

Iron work, of various kinds, as forks spoons, bits for briddles, dog-chains, and the like, are tinned by being scoured with sand, and put for some time into a pot of melted grain tin, covered with sal ammoniac.

Moirée, or Crystallized Tin Plate.

This beautiful article is made by taking tin plate, which has not been rendered too close in its texture by hammering or rolling, warming it, and then washing the surface with weak citric acid; or a mixture of two pounds of nitric acid, three of muriatic acid, and a gallon of water. The figures produced, vary according to the heat given to the plate; and a still more

beautiful effect is produced by heating particular parts of the plate by a blow-pipe.

The tin plate, when its surface has been thus crystallized, is varnished, either with clear, or coloured varnish.

Bronsed Iron.

The practice of coppering takes place in iron only. It may be done in the first place, by immersing the pieces of iron, if small, in a solution of vitriol of copper; but if they are large, they must be frequently brushed over with it. Secondly, it may be performed with copper-powder, which is laid upon a thin covering of varnish, and polished.

Browned Iron.

The barrels of fire arms are browned in the following manner:—

Nitric acid half an ounce, sweet spirit of nitre half an ounce, spirit of wine one ounce, blue vitriol two ounces, tincture of steel one ounce. These ingredients are to be mixed, the vitriol having been previously dissolved in a sufficient quantity of water, to make with other ingredients one quart of mixture. The mixture is to be applied with a clean sponge or rag; the barrel must then be exposed to a slight heat, after which, the barrel must be rubbed with a hard brush, to remove the oxide from the surface.

This operation may be performed a second and a third time, if requisite, by which the barrel will be made of a perfectly brown colour. It must then be carefully brushed and wiped, and immersed in boiling water, in which a small quantity of potash has been put. The barrel, when taken from the water, must, after being rendered perfectly dry, be rubbed smooth with a burnisher of hard wood, and then heated to about the temperature of boiling water; it will then be ready to receive a varnish made of the following materials:—Spirit of wine two pints, dragon's blood pulverized three drams, shell-lac bruised one ounce; and after the varnish is perfectly dry upon the barrel, it must be rubbed with the burnisher, to give it a smooth and glossy appearance.

Iron is sometimes browned in a simpler manner. It is merely rubbed over with water soured by aqua fortis; or by spirit of salt, and is then laid by until a complete coat of rust is formed. The iron is then rubbed with a little oil, and polished by means of a hard brush, and some bees' wax.

Copperas.

The English copperas, or green vitriol as it is also called, is made from the natural combination of iron with brimstone, called iron pyrites, or in common language, copperas stones, gold stones, or horse gold, from their colour.

These stones being collected in great quantity, are laid in heaps about two feet thick, upon a clay floor, surrounded by boards that direct the rain water that falls upon them, to flow into a cistern. The clay floors at some works, are 100 feet long, 15 feet broad at top, but narrowing to 12 feet at bottom, as they shelve gradually to allow the rain water to run off easier. The cistern usually contains about 100 tuns of water.

The copperas stones are five or six years before they yield any considerable quantity of strong liquor; the liquor being before that very weak. The sun and rain are the proper agents; for it has been found that other water, although prepared by lying exposed to the sun, and sprinkled on the stones, only retards the work. In time these stones turn to a vitriolic earth, which swells and ferments like leavened dough.

When a bed is come to perfection, it is refreshed every four years, by laying fresh copperas stones on the top. When a new bed is made, the work is hastened by mixing a good quantity of the old fermented earth with the new stones.

When the copperas liquor is 14 pennyweights strong, that is, weighs fourteen-eightieths more than an equal measure of water, it is esteemed rich; but in rainy seasons it is much weaker. The sulphuric acid is not saturated, as it will dissolve the shell of an egg in three minutes, and produce holes in any clothes on which it may fall or spatter.

The copperas liquor is boiled in leaden vessels, containing about 12 tuns; about a cwt. of old iron is put in at first, and more added as fast as it dissolves; amounting in all to nearly 15 cwt. in a boiling. As the water evaporates, fresh is added from a second boiler, heated by the same fire.

The boiling is esteemed finished, when a little of the liquor, put into an earthenware dish, and cooled; deposite crystals on the sides. The liquor is then run off into a tarras cistern, 20 feet long, 5 feet deep, 9 feet over at top, but tapered towards the bottom, where it is left for a fortnight to cool, and then drawn off, and reserved to be boiled with new liquor. There is generally a crystalline mass, five inches thick, left on the sides and bottom of the cooler, the copperas adhering to the sides is of a bright green, that at bottom foul and dirty. It is shovelled out upon a floor, and the liquor that drains from it is reserved along with the other.

If the furnace is well constructed, the copperas liquor moderately rich, and the water, that is added to supply the waste, is nearly boiling hot, three boilings may be made in a week.

In some works, iron is added to the liquor in the cistern; and of course less is required in the boiling.

There is another kind of pyrites, which contains a double proportion of sulphur; this sort does not alter by exposure to the weather, until the extra proportion of sulphur is removed either by roasting in piles, or by distilling in close vessels.

There is also a kind of bituminous earth that produces copperas by exposure to the air, and from which it may be obtained by washing with water in the usual manner.

Copperas is also manufactured by dissolving old iron in weak sulphuric acid, at 35 deg. Baumé, and crystallizing the solution.

Immense quantities of copperas are used for dyeing black colours, in the manufacture of common ink, and for many other purposes.

Copperas is the *sulphas ferrosus* cum aqua, of the Northern Chemists, or $\text{Fe} \cdot \text{S} \cdot 2 + 14 \text{H}^2 \text{O}$, and its weight 3,454,840; it is the *proto sulphate of iron* of Dr. T. Thomson, or $\text{Fe} \cdot \text{S} \cdot + 7 \text{H}^2$, equal to 17,575.

Copperas water is used to discover the presence of oxygen gas in a mineral water.*

Colcothar.

This red oxide of iron is obtained generally from the residuum of the distillation of saltpetre with copperas, for making aqua fortis, by washing it.

It is used for polishing iron or steel, and is sometimes called *trip* or *brown red*.

A superior kind is obtained by calcining copperas by itself, in a strong heat, in an earthen dish. The scarlet parts are called *rouge*, the red, purple, or bluish parts, being those which have been exposed to the strongest heat, are called *crocus*.

Jewellers' rouge is made by dissolving copperas in water, filtering the solution, and adding a filtered solution of pearl-ash, or of subcarbonate of soda, as long as any sediment falls. The liquor is then filtered again, and the sediment left on the filter, washed by running clean water through it, and then calcined until it is of a scarlet colour.

SILVER.

Silver does not admit of any varieties of denomination, like the preceding metals. Being very valuable, it is always re-

* For an account of the method of preparing the pyrolignite, or acetate of iron, (iron liquor,) co-extensively used in calico printing, see the article "calico printing," in this work.—AM. EN.

fined at the mines to a nearly uniform purity; and nothing but a small quantity of copper, and sometimes of gold, is left in it.

The purity or fineness of silver, is estimated in England by reference to what is called standard silver, which is an alloy of 11 ounces of pure silver, and one ounce of some other metal, generally copper, to the Troy pound; and is expressed by stating how many pennyweights and half pennyweights of pure silver, there is contained in a Troy pound of the mass, more or less, than in standard silver. In the first case it is said to be 1, 1½, 2, &c. dwts. better; and in the latter case to be 1, 1½, 2, &c. dwts. worse than standard.

Silver melted in an open vessel, absorbs oxygen from the air; but when it fixes, this oxygen, like the air from water in freezing, quits it; and this so suddenly, that the silver rises in vegetations, and is sometimes spurted out of the vessel.

The quantity of silver annually extracted from the mines of Europe and America, is about 850 tons.

Assaying of Silver Ores.

The value of silver, and the small quantity in which it is often found in its ores, require these ores to be assayed with great care. The ores of silver are, for this purpose, divided into three kinds.—1. *Ores of easy fusion*, under which are comprised native silver; the vitreous and corneous silver ores; the red and white silver ores; and some others.—2. *Wash ores*, which are mixed with stony matter, and must be separated from it by washing.—3. *Refractory ores*, which are either mixed with refractory materials, or with other kinds of ores, as cobalt, pyrites, or copper, in such a manner that they can not be separated from them by washing.

With respect to the silver ores of easy fusion, there are three operations chiefly to be attended to: roasting, scorification with lead, and cupellation. As to the roasting, there are, it is true, some silver ores that may be assayed without roasting, which are suffered to roast during the scorification by lead. It is, however, safer previously to roast the ore a little, particularly if it should contain a small quantity of sulphur or arsenic.

The scorification with lead, is performed in the following manner. One assay cwt. of ore is to be taken either before or after roasting, and eight cwt. of granulated lead added to it. First, one half of the lead is to be put into the clay test, or capsule; and upon this the ore, which is afterwards to be covered with the remainder of the lead. Immediately upon this, the capsule is to be put into a well-heated assaying furnace; at first, at the mouth of the muffle only, but at length quite into it;

and a red-hot coal is placed before the mouth of the furnace.

When the lead begins to melt, and the ore swims upon its surface, the mouth of the furnace is to be opened, the coal removed and the capsule drawn more forward, that the sulphur and arsenic may be better dissipated and expelled from the ore, After this, the test or capsule is again put into the furnace, a red-hot coal once more placed before the mouth of the latter, which is then shut up till the lead is seen quite bright and shining in the middle of the capsule, and the ore flowing round it at the sides.

As soon as this is perceived, the furnace is to be opened, and the capsule drawn forward again, that it may stand for about the space of a quarter of an hour in a moderate heat to fine. Afterwards, the heat is again increased as before, that the whole may enter into a smooth and thin fusion, and the whole matter stirred with a hook thoroughly heated, especially towards the sides of the capsule, so that the whole may be equally mixed with the matter in fusion.

When it is observed that the matter adhering to the hook runs off quite thin; that only a thin glassy pellicle is attached to the hook; that the slags towards the sides of the capsule are liquid and clear like oil; that the thick smoke has subsided; that a clear leaden vapour begins to appear; and that, to appearance, no more than about half the lead that was added remains in the capsule; the fire for the assay is then to be raised. In the mean time, a small hemispherical ingot-mould is to be rubbed over with chalk; the capsule is to be taken out of the fire, and the work, as it is called, immediately poured into the ingot mould.

Upon this the cupellation must commence. During the scorification of the ore with lead, two cupels must be inverted quite in the back part of the furnace, that their bottoms may become thoroughly red-hot: this is called breathing the cupels. When the scorification with lead is finished, the cupels being set upright in the furnace, are to be left there in the proper degree of heat, and the mouth of the furnace is to be closed again. The whole of the glass and scorix is then to be separated from the work which is to be hammered round. At the same time, a quantity of granulated lead is weighed out, equal to that which has been used in the scorification, which lead is called the weigh-lead.

The work is to be put into one cupel, and the weigh-lead into the other, and the same degree of heat is given to both, till the assay begins to look bright and clear; the assay is then to be conducted a little more gently, but not so that it shall

fix, of which the following are the most certain signs:—The appearance of a brown ring round the inside of the cupels; the vapour of the lead rising only a little above the brim of the cupel; a bright circle, like oil, is at times perceived encompassing the work; the appearance of several shining rays, at different intervals, round about the work. This degree of heat must be continued till the quantity is diminished to about half: after this, the fire must be gradually increased, till the button lightens. When this has taken place, the cupel is left in the furnace till the button is fixed, that it may not be divided into a number of small buttons, by being taken out too soon.

As soon as the assay is become solid in the furnace, it is taken out, and the button immediately detached from the cupel by a stroke with the point of the cupel tongs, before it adheres too fast. The same method is to be pursued with what remains of the weigh-lead in the other cupel. After this, the amount of the latter must be subtracted from that of the former, and the remainder only set down as the contents of the assayed quintal.

The above-mentioned cupellation of the mere weigh-lead, must be undertaken at the same time; on account that nearly all lead contains a small quantity of silver. By this means, the amount of the silver it contains is ascertained, and subtracted from the actual product of the assay of the ore, to which it necessarily must have adhered from the lead that was added.

Wash ores, which are interspersed in stones and matrices of ores, must be previously freed from them as much as possible, then stamped tolerably fine, washed, and roasted. An account having been taken of the loss sustained by the ore in the washing and roasting, an assay cwt. of the roasted ore is to be weighed out, a cwt. of glass of lead, made by melting litharge with half its weigh of calcined flint, and twelve of granulated lead are to be added to it. The processes of scorification, and cupellation ore, are then conducted as usual.

Refractory silver ores, which cannot be washed, must first be exposed for some time to a red heat, and roasted. After this, they are to be mixed with the very same ingredients, and those in the same proportion as has been mentioned of the wash ores. They require a brisker fire in the fusion and scorification of them by lead. The work thus obtained, is then to be cupelled.

For assaying various kinds of earths and stones for silver, one assay cwt. of these is to be mixed with the same quantity of glass of lead, then scorified and cupelled with 12 cwt. of lead. Or these three ingredients are to be mixed together in

equal parts, covered with common salt, and brought to perfect fusion; or one part of these stony substances may be fused to glass in a crucible, with two parts of litharge or minium, in a forge fire, which glass is afterwards to be powdered, mixed with twice its quantity of black flux, then fused afresh, and the regulus of lead thus obtained submitted to the cupel.

It often happens that melted metals contain a portion of silver, and must be assayed to know what proportion they contain.

With this view, regulus of antimony is scorified in a test or capsule, in a very gentle heat, with eight or ten times its quantity of lead, till the colour of the fumes is altered, which in this case is usually brown, and the gray fumes of lead appear, when it is suffered to stand half a quarter of an hour longer. The lead is then separated from the scorizæ, cupelled, and the silver button weighed.

Zinc is calcined by itself in a crucible, and an assay cwt. of it scorified and cupelled with two cwt. of glass of lead, and twelve of lead.

Bismuth is mixed with from four to six times its quantity of lead; and in every respect treated like regulus of antimony; the fumes arising in the scorification of it by lead, are only inclining to brown.

To assay iron for silver, to half an assay cwt. of iron, one cwt. of sulphur is to be added, and put into a capsule rubbed over on the inside with chalk, which after being covered with another, must be placed quite in the fore part of the assay-furnace, and roasted with a gentle heat. When the sulphur is expelled from it, the residuum is weighed out, with eight times its weight of lead, for the assay, scorified in the capsule, and then submitted to cupellation.

The assay of lead for silver is easily conceived. If the lead contains an ounce of silver in the ton, it is considered worth separating.

To assay tin, half an assay cwt. of it is to be added to two cwt. of lead. This is to be set forward in the mouth of the furnace, so that it may become a little red: after a short time, the tin covers the surface of the lead in the form of a gray calx. This gray oxide is to be taken off by little and little with an iron ladle, and pushed towards the sides of the capsule till the whole is calcined. All the oxide of tin collected together is to be mixed with an equal or twice the quantity of glass of lead, and again put into the furnace in a capsule. After which, a quantity of lead is to be added to it, equal to ten times the weight of the oxide of tin, and the whole to be scorified and cupelled, like a refractory silver ore.

to mix the ore and water, there are added to each 5 cwt. of quicksilver, and 70 pounds of iron forged in circular plates.

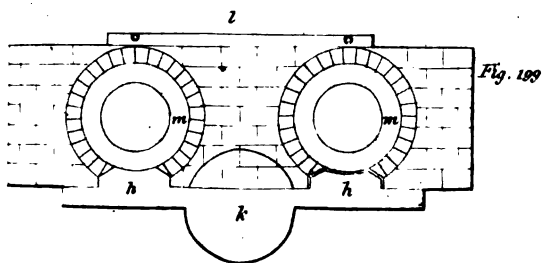
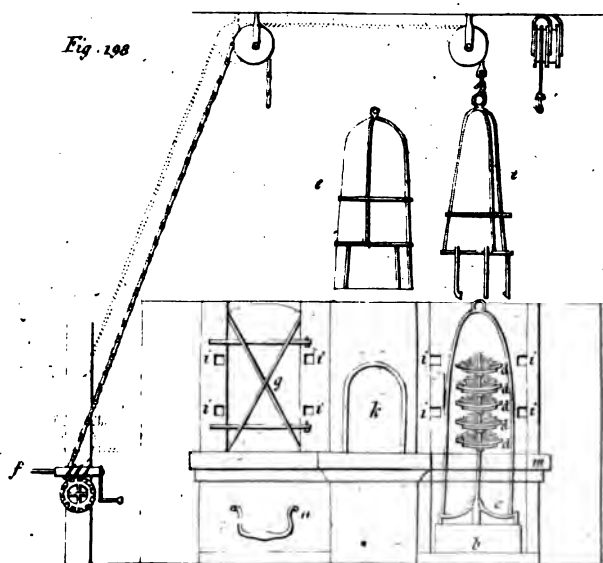
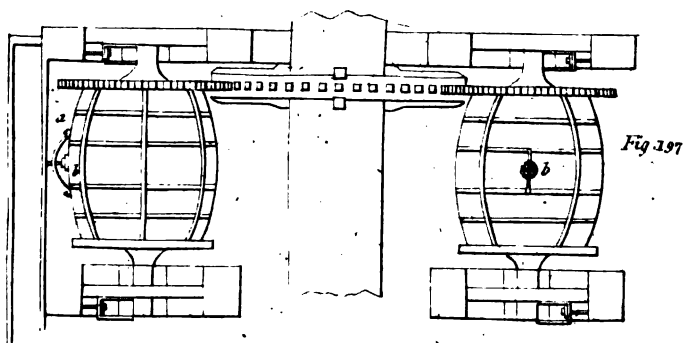
The barrels make 18 or 20 turns in a minute, and are turned for 18 hours, when they are thrown successively out of gear, and the bung hole being opened, a wooden pipe is inserted in it, with a short length of leather hose, closed at the end by a screw cock. The barrel thus fitted, is turned half round by the hand, and the hose being placed in the gutter, the cock is opened, and the quicksilver run into a filter of ticken, through which the liquid quicksilver runs into a cistern, to be used over again; and the amalgam remains on the filter.

The barrel being again turned, with its bung-hole uppermost, is filled with water, and stopped, then thrown into gear to mix the whole, and afterwards emptied in a similar manner, of its contents, into gutters that convey them to the washing-house.

The amalgam that remains on the ticken filters, is composed of six parts of quicksilver and one of silver, and is distilled to separate the two metals.

Fig. 198, represents partly the elevation, and partly the section of the apparatus used for distilling the amalgam; while fig. 199, exhibits the plan. *A*, is a wooden drawer, which can be drawn out by means of rollers. *B*, is a cast iron basin, placed in this drawer to receive the quicksilver. *C*, is an iron pillar, with four legs, standing in the cast-iron basin. *D*, are five plates of forged iron, with a hole in their middle to slip over the iron pillar, and are supported by it at some little distance from each other, by the upper half of the pillar, in the manner of a dumb waiter. *E*, are cast-iron bells, about four feet high, hooped and bound with forged iron and furnished at top with a ring, to receive occasionally the hook of a crane, by which they may be lifted in and out of the furnace. *F*, is the crane. *G*, is an iron door, lined with clay, which is placed against the opening in the front, when the bell is fitted in its place. *H*, are the openings in front of the furnace, by which the pillar and dishes are put in, and taken out of the furnace. *I*, are the openings by which the fuel is supplied with air. *K*, is a projection and recess of the masonry, between every two furnaces, of which there are four serving as a table, on which the dishes are filled or emptied. *L*, is a gutter behind the furnace, by which a stream of water is conveyed into the drawers. *M*, is a cast-iron plate, resting partly on the bell, and partly on a ledge in the masonry, and serving as a bottom to the fire room.

The drawer of each furnace being thrust in, and the cast-iron dish and pillar placed in it, 3 cwt. of amalgam are placed on the dishes, which are then fixed on the pillar; the bell let down so as to rest on the legs of the pillar, the iron plate that forms the bottom of the fire room placed, the front door applied and fastened, and the water let on to fill the drawer, thus entirely covering the basin and bottom of the bell; a fire is lighted in the fire room, which is brought on gradually—at first turf is used, and afterwards charcoal. The distillation usually lasts eight hours, and is ended when the drops of quicksilver are no



longer heard falling into the iron basin. During the whole time, a stream of cold water is kept running into the drawer, and escaping by its upper edge.

The bell being cold, it is raised up, the silver left on the dishes removed and melted into cakes of 20 or 25 pounds each, ready for cupellation, and the quicksilver collected in the basin, dried by a sponge, and returned for a fresh amalgamation. The silver usually contains three-sixteenths to five-sixteenths of alloy, being either copper, cobalt, nickel, or such other metals as were contained in the ore; there is usually 550 or 600 pounds obtained every fortnight. The quicksilver retains some silver, but this is of no importance, as it is used over and over again; and there are two parts in 100 of the quantity of quicksilver used, lost in each process.

The residue from which the amalgam was run, and which was washed out of the barrels, is received in large vats, six feet in diameter at top, and the same in depth, having eight plugs at different heights. In each vat an upright spindle is worked, having several iron arms, by which the matter is stirred. The washing is continued for 12 hours, and then the residue is drawn off into waste pits by opening the upper plugs; for those near the bottom are not opened above once in three weeks, when the quicksilver that remained in the mass is collected. After the earthy matters in the pits have subsided, the water is pumped off, and evaporated, by which means a quantity of Glauber's salt is obtained.

The quantity of ore annually operated upon, is about 60,000 cwt., and there is obtained from 140 to 145 cwt. of silver. The substances consumed are, about 25 cwt. of quicksilver, 6000 cwt. of salt, 60 to 80 cwt. of iron, and 345,000 cubic feet of charcoal. The expense is nearly the same as in smelting, the only advantage being the lessening of the consumption of charcoal, and thus keeping down its cost to the works, in which it must necessarily be employed.

The ores worked in Europe for silver, are not properly ores of silver, but lead and copper ores, which hold a small portion of silver. Hence these ores are first smelted for their lead or copper, and then these metals are worked to extract what silver or gold they contain.

For the purpose of separating silver from lead in a large scale of manufacture, recourse is had to cupellation.

The Hartz furnaces, used for cupellation, have a moveable cupola, which facilitates the making of the bed on which the lead is kept in bath.

Fig. 200 represents the elevation of this furnace, taken opposite to the fire room door. Fig. 201, is the elevation of the side of the furnace, taken oppo-

site to the charging door. Fig. 202, is the plan at the level of the blast holes. Fig. 203, is the vertical section in the line * * of fig. 202.

In these figures, *A*, is the masonry of the foundation, *B*, are channels for carrying off the moisture. *C*, are stones for covering these channels. *D*, is a bed of slag. *E*, are the bricks which form the bottom of the bed. *F*, is the bed, 9 feet in diameter, which is made, when wanted, of wood ash, generally obtained from the soap boilers, well washed and pressed together. *H*, is the cupola, made of sheet iron, slung to a crane; this cupola is lined on the inside, about two inches thick with clay. *I*, are the blast holes, by which the wind from two bellows is blown upon the bed; the bellows have loose nozzles, so that the direction of the blast may be altered at pleasure. *K*, are the bellows. *L*, is the door by which the bed is charged with the lead to be cupelled. *M*, is the fire room door; *N*, is a small opening, by which the scum of the bath, and the litharge is let to run out of the bed. *O*, is a basin made for security in case of accidents: this basin is generally covered with a stone, over which the litharge runs; but sometimes the stone is removed, and the lead is run off the bed into this basin.

The bed of the furnace takes about 35 cubic feet of wood ashes, and two hours and a half to make it; at the same time the cupola is lined with clay. The bed is then charged with 84 cwt. of lead, half of which is placed opposite the blast holes, and half near the bridge between the fire room and the bed; to this latter is added any thick slags holding lead and silver, so that they may be brought into use. The cupola is then moved over the bed and luted to the furnace, which is first heated very gently with fagots, and as it dries the fire is increased.

In about three hours the lead is melted, it is then watched, and as soon as there is no longer any boiling observed on the surface of the bath, the bellows are set in motion, and blown about four or five times in a minute. At the end of five hours, the fire is increased, and the first gray scum is drawn off through the small opening; the running off of this scum continues for about an hour and a half, and charcoal powder is thrown upon it to coagulate it, as it is drawn to the opening by a hook.

The litharge then begins to run, and the workman makes a gutter in the edge of the bed, to facilitate its running. During this time the blast is so directed as to produce circular waves on the bath, so as to drive the litharge as it forms to the circumference, and particularly to the opening by which it runs off.

When the litharge has run for about 12 hours, and it begins to form only on the edges of the bath, the litharge that forms afterwards is kept apart, as it contains silver. About this time, the heat is augmented, and a brick is placed before the opening by which the litharge runs out; the use of this brick is to keep a reserve of melted litharge at hand in case that surrounding the bath should be suddenly absorbed by the bed, also to keep in the water that is afterwards introduced, and finally to keep in the silver, in case of any detonation or other accident hap-

pening, until the stone over the basin is removed. The litharge that collects behind this brick is jerked out of the opening by an iron hook.

When the operation has lasted about 20 hours, the silver, now nearly left pure, appears to form a nearly circular cake: and at length its surface brightens instantaneously, immediately on which a wooden trough is introduced, and water, warmed by throwing red hot iron into it, is poured on the silver.

Some workmen use only 300 billets of wood, each one cubic foot .8, in this operation; others, less skilful, use 400 billets, or even more: on an average, 100 cwt. of lead consumes 790 cubic feet of billet wood in cupellation.

The products obtained from 84 cwt. of lead, are generally 24 to 30 marks, or half pounds, of silver, retaining seven marks, one ounce and a half of alloy in each 100 marks; 50 to 60 cwt. of pure litharge; two to six cwt. of the second litharge, retaining a little silver; four to eight cwt. of the first scum; and 22 to 30 cwt. of the upper surface of the bed, which is impregnated with litharge.

The loss of lead is calculated at three or four pounds in every 100; but lately the hoods under which the cupelling furnaces are built communicate with chambers, in which the lead smoke that formerly flew away, is condensed.

Trials have been lately made in the Hartz to improve this process. In the furnace cupelling 100 cwt. of work lead at once, there was a saving of one quarter of the fuel and wood ashes, the produce of litharge was increased four pounds in every 100, while the silver was as usual.

In a furnace cupelling 200 cwt. of work lead at once, there was a saving of fuel and wood ashes, but the quantity of litharge and silver was very variable.

In a furnace built at Altenau, to cupell 500 cwt. of work lead on a single bed at once, by means of two fire rooms and four openings for the running off the litharge, the silver did not form a single cake, but part remained on the edges of the bed, nor could the sudden brightening of the silver be produced properly.

In another double furnace with two fire rooms, and their beds placed side by side, and holding 250 cwt. of work lead each, the brightening indeed took place, there was a saving in fuel and wood ashes, and sometimes a large produce of litharge, but the quantity of silver obtained was not satisfactory.

From these experiments the Hartz smelters have concluded that it is not profitable to cupell more than 100 or 110 cwt. of work lead at once: and several still prefer the old furnaces that cupell only 72 cwt.

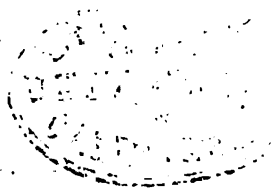
In the Hartz works the operation of eliquation, or sweating cakes of copper that hold a small quantity of silver, is begun by smelting through a blast furnace, and moulding into cakes about 30 separate charges each, containing 90 to 96 pounds of black copper, containing at least two ounces and a half or three ounces of silver in the cwt. along with two cwt. of lead reduced from litharge, and a half cwt. of litharge. The smelting is begun by a charge of slags, then the litharge is added, and when the lead begins to flow out, the copper is put into the furnace, and again as soon as the copper flows, the lead is put in, in order to mix the metals properly.

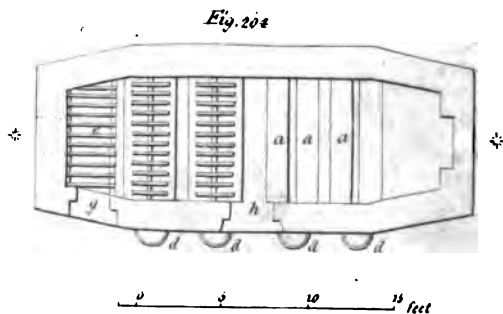
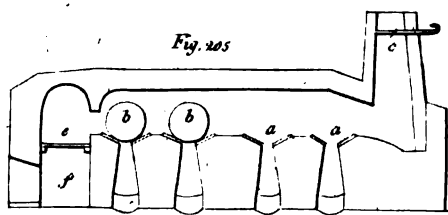
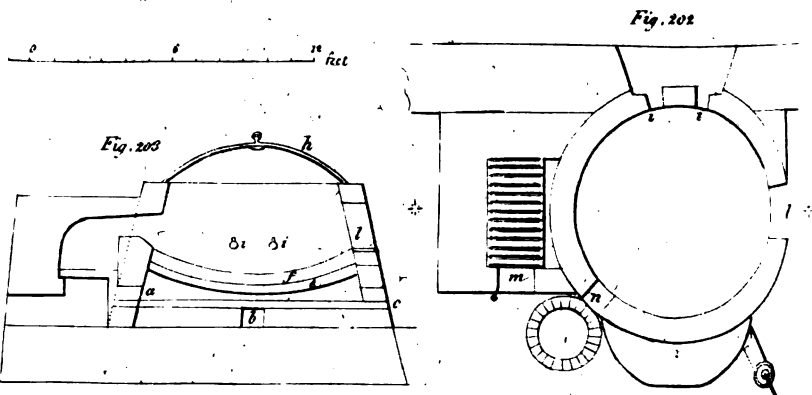
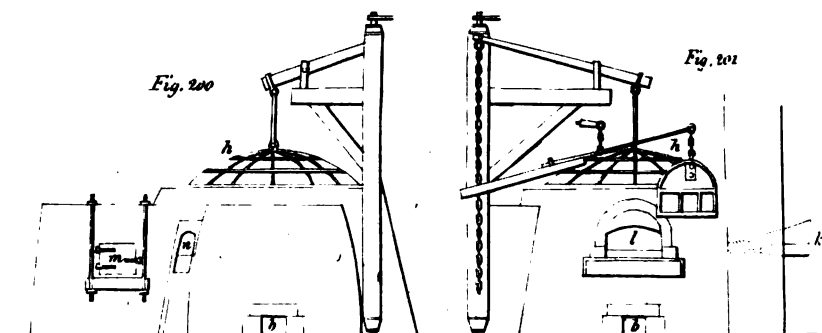
When the operation is in good train there are three cakes for sweating at once in the furnace, each composed of a single charge; one moulded in a cast iron or lower basin, another ready to be moulded in the upper basin, and a third nearly ready to be run out of the furnace into the upper basin. The smelting of 30 cakes for sweating consumes about 12 cwt. of the best charcoal.

In the Hartz furnace, the first sweating is done upon a plain open hearth, the top of which slopes from each side to the middle and forms a gutter. In general eight cakes are sweated at once, and are separated from each other by a bit of wood about two inches long. The charcoal is heaped over the cakes, and prevented from falling by iron plates placed on the sides and front, and when the wood that separates the cakes is burned, the charcoal falls between them. The operation generally lasts three or four hours, and one cwt. and a half of charcoal is consumed. The lead melts and carries with it a considerable portion of the silver contained in the copper. If on assaying the lead it is found not to contain two and a half or three ounces of silver in a cwt. it is smelted over again with fresh black copper; but if sufficiently rich in silver, it is destined to the cupelling furnace.

After the copper cakes have been sweated on the open hearth, they are sweated a second time in a close furnace. This furnace is composed of two thin walls in the body of the furnace, which serve along with the sides to support the cakes of sweated copper, and these are the spaces between these walls in which the billets that heat the furnace are thrown. As also, vents by which the burned air that enters by openings, opposite to those in the back wall, into upright flues, which terminate in a single large chimney. The front of the furnace is closed by a large iron door.

In the Hartz, 30 cwt. of cakes that have been sweated on the open hearth, are placed in this furnace, which is then filled





with wood and the door kept shut. About 80 or 90 cubic feet of resinous wood are consumed in the 15 or 20 hours' fining. At the end of 24 hours, the cakes are taken out, cooled in water, the fragments and silvery scales that stick to them are struck off by the hammer, and the cakes sent to the refining house. The slags and lead that run out of the furnace are laid by, and smelted with other copper.

As much of the heat is lost in the operation when performed on an open hearth, reverberatory furnaces have been constructed in Saxony for performing it.

Fig. 204, represents the plan of this furnace, as built at Hett Staedt, in Mansfield, and fig. 205, is the vertical section in the direction * *. *A*, are the four hearths, each formed of two inclined plates of cast iron, that are united together sideways, and form the chamber of the furnace; *B*, are the cakes as they are placed on their sides on the hearth. *C*, is the chimney with its damper. *D*, are the basins into which the lead that sweats out of the copper is collected. *E*, is the grate. *F*, is the ash room. *G*, is the fire room door. *H*, is the opening into the chamber of the furnace, by which the cakes are put in and taken out.

In these Saxon furnaces 200 cwt. of sweated copper cakes are put into the furnace, which is heated with wood and a little charcoal. At the end of six hours the slags and lead are run out, and this repeated every two hours afterwards. The whole operation lasts about 26 hours, and there are consumed 1330 cubic feet of cleft resinous wood, and 15 cubic feet of charcoal. The first slags contain about 30 pounds of lead, three of copper, and two ounces of silver, in a cwt. the next contain more and more oxide of iron; the last are red, glossy, and contain 15 pounds of lead, 12 of copper, and $\frac{3}{4}$ of an ounce of silver. The cakes are then taken out, cooled in water, and the slag that sticks to them carefully separated, as it contains about two ounces of silver in a cwt. The copper cakes by this operation are reduced to about 160 cwt., and still hold nearly a $\frac{1}{2}$ an ounce of silver in the cwt.

Silver refined by Charcoal.

Agatharcides says, the gold of the mines between the Nile and the Red Sea, was refined by cementation for five days with lead, salt, tin, and barley meal, the use of the barley meal was difficult to explain, until Hellot observed a similar process used in the mint at Lyons; one of the three mints from which the wire drawers of France are obliged to purchase their rods of silver. A layer of three inches of small pieces of charcoal is kept at the bottom of a crucible by a false bottom; 60 lbs. of silver in ingots are melted in this crucible, and kept in fusion for seven or eight hours. The vapour from the charcoal causes it to boil as violently as water on a quick fire, although silver alone, melted in an equal degree of heat, had only a slight motion at the surface. This mode of refining furnishes very pure silver, perfectly free from lead; the process is evidently analogous to the poling of copper and iron.

Silver reduced from Muriate of Silver.

In many operations of chemistry, the muriate, chlorure, or chloride of silver, formerly called Luna cornea, or horn silver, is formed. Silver being a valuable metal, this is generally saved, and may be considered as an artificial ore of that metal.

To obtain the silver, the common method is to moisten the muriate of silver and form it into a ball, some pearl-ash is then put at the bottom of a crucible, the ball laid upon it, and covered with more pearl-ash: the whole is then exposed to a gradual heat, until the silver is reduced and melted.

The muriate of silver may be still better mixed with one-fifth its weight of dry quick lime, and one-twentieth of charcoal in powder, and heated till the silver is reduced.

The silver may also be obtained by covering it with a small quantity of water soured with sulphuric acid, or muriatic acid, and putting into the water a bright piece of iron, or of zinc.

Silver Plate and Coin.

In England all silver plate and coin are made of one uniform alloy, of eleven parts of silver and one of copper; which is called English standard silver.

Silver plate is usually cleaned by being coated over with whiting and water, and when the coat is dry, rubbing it off with a brush or soft piece of leather; but this does not give it any polish. A paste of levigated calcined hartshorn, or levigated bone ashes, with spirit of turpentine, used in the same manner, not only cleans the plate, but gives it a brilliant polish. The silversmiths boil the plate along with a powder composed of equal parts of white argol, saltpetre, and alum, which gives the plate a brilliant whiteness. Some use spirit of salt, which causes the plate to have a black polish: this black polish is still better given by calcined clunch of the Staffordshire mines, called trip, which causes the plate to shine like polished steel.

In France, the silver coinage is an alloy of nine parts of silver with one of copper, or, as they express the fineness, it contains nine hundred thousandths of fine silver. They have also another set of coins of small value made of *billon*, which is an alloy of one part of silver, with four of copper, that is to say, it contains two hundred thousandths of fine silver. The French table services of silver are alloys of nine and a half parts of silver, with a half part of copper, so that it contains nine hundred and fifty thousandths of fine silver. Their sil-

ver toys are made of an alloy of eight parts of silver with two of copper, so that they contain eight hundred thousandths of fine silver.

A great difficulty occurs in melting silver at the mint, partly on account of the quantity required daily, the sorting together of ingots weighing 50 or 60 Troy pounds, so as to produce a mass of standard, but still more from the metal becoming finer during the process of melting, and thus the alloy rejected by the assay master, so that it must be remelted with worse silver, to the great loss of the melter, who is paid by the pound fit for rolling.

Some of the French mints melt in forged iron pots, which absorb, the first time they are used, a part of the silver; and it is suspected that they were used in the English mint during the great recoinage in the reign of William III., as the silver was then melted in parcels of 400 Troy pounds.

Other French mints, as that of Lisle, melt the silver in the chamber of a reverberatory furnace, and taking out from time to time, samples for assay, add copper as the silver refines, so as to enable the melter to keep the metal to the proper standard during the time it is lading out and casting into bars.

In the English mint, since 1811, Mr. Morrison has succeeded in melting 10,080 Troy pounds daily, in eight furnaces, with eight men.

The melting furnaces are cylindrical, 30 inches deep and 21 inches in diameter; the grate bars are moveable; the flue is nine inches square, and 45 feet high. On the grate is placed a cast-iron cheese, concave at top, two inches wider than the mouth of the pot, and two inches thick: this cheese is covered an inch thick with coke dust, to prevent the adhesion of the pot.

The pots are of cast iron, of sufficient size to melt 500 Troy pounds of silver, but charged on an average with only 420: on the mouth of each is placed an iron ring, or muffle, six inches deep, to allow the fire to be heaped up, and also the silver ingots to be heaped up above the rim; the cover is a flat plate of cast iron.

The pot is first put in its place, and some lighted charcoal on the grate, on which three inches in depth of coke are placed; when this is lighted, three inches more are added, and thus the pot is so gradually heated, that it is generally two hours before it can be brought to a charging or bright red heat. A mass of cold iron is then held in the centre of the pot, to enable the melter to see if it has cracked in bringing up, as any crack would by this means be rendered visible. The pot is then charged, coarse grained charcoal powder being added to

coat the inside of the pot, and prevent the silver from adhering. As soon as the silver melts, more charcoal powder is added to the float, half an inch deep on the melted metal, and prevents its refining. When the melting is completely finished, the metal is stirred with an iron rod, the pot taken out by means of claws and a crane, and its contents poured into the cast-iron ingot moulds, which are previously heated in an iron closet with flues, and rubbed on the inside with linseed oil. Three meltings are worked daily in each furnace.

The ingot bars require to be annealed, by being heated to redness in a reverberatory furnace before they can be rolled. After rolling, the silver is again softened by a similar annealing; boiled in very weak sulphuric acid, and dried with warm saw dust.

Solder for Silver.

This is made by melting three parts of silver with seven of copper, or four of silver with six of copper.

Silver gilt Plate.

Silver is gilded in the same manner as copper, but with an amalgam of gold.

Nitric Solution of Silver.

This is prepared by dissolving granulated silver in nitric acid, sp. gr. 1.500, diluted with an equal weight of water, until no more silver is taken up.

It is used to prepare the Lunar caustic of the surgeons, and to ascertain the presence of muriatic acid in mineral waters.

The Lunar Caustic.

This mystical phrase merely denotes the salt obtained by evaporating gently the nitric solution of silver to dryness, in a silver vessel, continuing the heat until it melts, and when in quiet fusion, pouring it into moulds, to cast it into sticks, the size of the barrel of a common quill.

Sulphate of Silver.

This sulphate is best made by adding subcarbonate of soda to a nitric solution of silver, to throw down the carbonate of silver, and then dissolving this carbonate in weak sulphuric acid.

It is used to ascertain the presence of muriatic acid in mineral waters.

Acetate of Silver

Is formed by dissolving in hot acetic acid the carbonate of silver, which is precipitated when subcarbonate of soda is added to the nitric solution of silver.

It is also used to ascertain the presence of muriatic acid in mineral waters.

Detonating Silver.

This is made by putting a sixpenny piece into a flask, and pouring upon it an ounce and half of nitric acid, spec. grav. about 1.35. When the silver is dissolved, two ounces of spirit of wine are to be added, the liquor is carefully heated over a lamp, and the detonating silver soon appears to be deposited in

white crystals. By degrees two more ounces of spirit of wine are added, and when the boiling ceases, the liquor is decanted, and the detonating silver washed by pouring water upon it, and decanting the water several times; it is then to be carefully dried, with a heat not exceeding that of boiling water.

Detonating silver explodes on being exposed to a heat above 266 deg. Fah. or by the slightest shock between two hard bodies: it must therefore be managed with a wooden knife, or one of card paper.

It is used mostly for amusement, but may be applied as an alarm, by a paper or glass bubble containing some of it being placed where a person is suspected of going for improper purposes.

GOLD.

The greatest part of the gold in the possession of mankind has been found in the form of sand in the beds of rivers, and is separated from the other sand by washing in dishes, or on tables. This in Europe is principally done by the gipsies.

Gold ores, as they are improperly called, are only veins of sulphuret of silver, holding a little gold: the mines of Mexico and Peru, as well as those of Hungary and Transylvania are of this nature. The mines of America furnish yearly about 34,500 pounds of this metal, and those of Hungary and Transylvania about 2,800 pounds.

The fineness of gold in England is estimated by reference to a certain standard, being the alloy of eleven parts of gold, and one of some other metal, and is expressed by saying that the gold spoken of is so many carats, or twenty-fourth parts of a pound, so many grains, or quarter carats, and so many quarters of a grain, in a pound Troy, better or worse than standard gold.

In France the fineness of gold is expressed by stating how many thousandth parts of the mass consist of gold.

Assaying of Gold Ores.

There is properly no assaying of ores for gold in the first instance. The silver ores that contain gold, are first assayed for the silver they will yield, and if this is sufficient to pay the charges, they are smelted and cupelled, and the silver thus obtained is assayed for the gold.

Gold dust, as it is called, is assayed as gold itself, which holds a little silver or copper, by first cupelling a portion of it with lead, as in assaying silver, and then flattening the bead, rolling it up, and then examining the quantity of gold in this plate.

When the silver to be examined contains but a small quantity of gold, of which a judgment may be formed by rubbing it on the touchstone, a little of it previously rolled out, is dissolved in nitric acid, when the gold contained in it is left behind undissolved, in the form of a brown or black calx, which is heated until it acquires the proper colour of gold, and then weighed.

But when there is a greater quantity of gold in the sample than of silver, the gold is separated from the silver as perfectly as can be done, by solution in aqua regia.

In the first case, however, a residuum or arrearage of silver remains behind, united with the undissolved gold, and in the second instance a residuum of gold is left in the undissolved silver. The cause of this is, that gold and silver defend each other mutually from the action of the menstruum, when part of the one is enveloped in an exceeding small quantity in the other.

These arrearages, according to Schluter and Cramer, scarcely amount to one one-hundred and fiftieth or one two-hundredth of the mass. By this observation it has been discovered farther, that neither aqua fortis nor aqua regia can effect a perfect separation in an alloy of gold and silver, unless these metals be mixed together in a certain proportion. But when one part of gold is alloyed with three parts of silver, silver may be dissolved by nitric acid, properly diluted, so that only the gold, with a very small arrearage of silver, shall remain behind undissolved. This is called separation by quartation, or simply quartation.

Now, in order to attain this end, the quantity of gold contained in the silver must first be ascertained by the touchstone. In case that the gold should amount to more than one-fourth, so much silver must be added to the mass, and fused with it, as is sufficient to produce the above-mentioned proportion; and then the quarded metal is rolled out, dissolved in nitric acid, the residuum of gold heated to recover its proper colour, and weighed.

The separation of platinum from gold, is effected by pouring into a solution of this alloy, made by a mixture of nitric acid with the muriatic, a solution of sal ammoniac, when the platina is precipitated alone, after which the gold, may be thrown down separate by copperas water.

Extraction of Gold.

As gold is not extracted direct from its ores, but from silver, which contains a certain portion of it, or from gold dust, the processes for extracting it are the same as those of assaying for gold: except in the parting by means of sulphur, or dry parting, as it is called, used in the Hartz, which cannot be performed upon a small quantity of materials.

When a metal contains a large proportion of gold, united with silver, copper, or lead; the gold is separated from the lead and copper by cupellation, and from the silver by parting.

By these means the gold is obtained from the metal obtained from poor gold holding metal, by means of sulphur and litharge, as already related; also from the native gold dust collected from the sands of rivers, by the negroes of the Gold Coast of Africa,

and by the gipsies of Europe; and from old gold plate, coins, and trinkets of that metal.

If the gold contains no silver, which is rarely the case, cupellation alone, with a proper quantity of lead, as in the case of silver, is sufficient; but if the metal contains silver, it is necessary first to get rid of the copper and lead by cupellation, and then manage the matter so that the metal may contain one-quarter in weight of gold, and three-quarters of silver: an operation which is called quartation. If the silver is in too large quantity, part of it must be removed by means of sulphur, and if it is in too small quantity, a sufficient quantity of pure silver must be melted with the metal, and then the quarted metal may be parted with aqua fortis.

The gold being quarted, is separated from the silver it contains by parting with aqua fortis. For this purpose, in a large way, it is melted, and being ladled out with a small three-cornered crucible, it is poured in a fine stream into cold water, and thus reduced to grains.

About six pounds of this granulated gold is put into a glass bolthead, the bowl of which is coated with clay; and this being placed in a sand bath, aqua fortis is poured in, so that the gold is entirely covered. A gentle heat is applied, and when the acid appears to be saturated, it is drawn off, and fresh poured on, until it has no action on the metal. The fire is then withdrawn, and when the furnace is cooled, the remaining gold is washed with hot water, until the water comes off tasteless: the washings are collected together in a copper basin, and salt added to separate the silver they contain, as muriate of silver; the washed gold is carefully dried, melted with a strong fire, and cast in ingots: it is 23 carats eight-twelfths fine, and very ductile.

The aqua fortis that is drawn off, is distilled in glass retorts. The distillation in the Hartz works lasts several days. The fire is at first very gentle; when red vapours appear, the apparatus is luted, and the fire increased. Towards the end, some nitrate of silver sublimes in whitish flowers, adhering very fast to the neck of the retort. The distillation being finished, the retort is broken, the flowers and glass to which they stick are melted with a little litharge, and thus a button of silver is obtained. The residuum of the distillation is carefully collected, and together with the button just mentioned, is added to the lead obtained in remelting the sulphuretted iron, arising from separating sulphur from silver by iron, and cupelled, as already stated: the product is fine silver.

As the silver obtained by cupellation from the lead and copper ore of the Hartz mines contains a very minute portion of gold, this is separated by means of sulphur or dry parting.

The silver is melted in portions of 100 or 150 pounds in a black melting pot, kept melted about two hours, ladled out with a small crucible, and poured into cold water kept stirred. The silver thus granulated is distributed into wooden dishes, and dusted with one-eighth its weight of sulphur: the grains are then shaken to distribute the sulphur equally.

On remelting this silver it divides itself between the sulphur and the gold; the sulphuretted silver swims at top, and the alloy of gold and silver. When the mass is perfectly liquid, about one-sixteenth or one-twelfth of litharge is strewn on the surface; the litharge is reduced, and part of the lead unites with the sulphur, while another part uniting with the silver thus separated from the sulphur, passes through the melted sulphuret, and carries down with it into the metallic button any particles of gold that remain suspended in the sulphuretted silver. The crucible is left to cool, and then as the separation of the button is not distinctly marked, the sixth part of the height of the ingot is struck off, and laid aside.

The sulphuretted silver, or upper part of the mass, is remelted with fresh sulphur, and only one-thirty-second of litharge. The sulphuretted silver obtained in this second melting is assayed, and if it contains ever so little gold, it is melted a third time with fresh sulphur and litharge. The buttons struck off in these remeltings are added to the former.

The buttons of impure gold thus obtained, are melted together, granulated, and again worked with sulphur and litharge as at first, until, by assaying the button, it is found to contain not more than five or six parts of alloy, partly silver and partly lead, to one of gold: at which time the metal is generally reduced to 15 or 20 pounds. The gold is then refined by cupellation, quarting, and parting by aqua fortis, as in other cases.

The masses of sulphuretted silver are every six months collected, and melted in large crucibles with one-fourth their weight of iron, and left to cool. The upper part of the mass is sulphuretted iron, the lower is composed of six-sevenths of silver and one-seventh of lead, which are separated by cupellation. The sulphuretted iron is remelted with one-tenth of iron, and when completely liquid, dusted over with litharge, which is reduced and the lead falling through the melted mass carries with it a small portion of silver. The button thus obtained is cupelled separately along with the refuse matters of the parting, and yields fine silver. The sulphuretted iron that swam over this button is mixed with the broken crucibles and other refuse matters, as also the impurities arising in the last-mentioned cupellation, namely, the litharge, bed, and scum, are smelted, and yield a button of lead, which is cupelled, and the silver reserved

and added to the next parcel of raw silver that is to be operated upon. The impurities of this cupellation are laid aside, and added in the smelting of the next parcel of sulphuretted iron.

By this series of operations, there are annually separated with some profit four or five pounds of gold, from more than 200,000 cwt. of ore.

Another mode of separating a small portion of gold from a large portion of silver is now in use among the refiners at Paris.

As fast as any new parcels of silver are brought to these refiners, they proceed to separate the small quantity of gold, which would otherwise be neglected, and which they estimate upon an average to be one-tenth per cent. of the weight of the silver. Now if the many thousand ounces of silver which are annually melted, are calculated, it will easily be seen how much gold is thus procured, which would otherwise be left in the silver, and lost to the world and its owner.

Upon a number of stove holes, of a foot in diameter, there are placed platinum eggs, each of which contain 8lbs. of granulated silver, and 12lbs. of oil of vitriol. All these eggs are covered with a high cap of the same metal, with a small opening, a quarter of an inch over, at top, to let out the vapours. These stoves are arranged under a hood, which opens into the chimney of a furnace, in which a fire is kept for the purpose of producing a strong draught of air from the hood into the flue, to carry off the vapours.

As the sulphuric acid does not act upon silver, unless heat is applied, a fire is lighted in each of the stoves; at first the solution goes on very fast, and much sulphurous acid gas is disengaged, but after two or three hours, the solution goes on slower, and it requires 15 hours in general to complete the solution.

The vapours exhaled in this dissolution of the silver, is not only sulphurous acid gas, but also those of sulphuric acid itself; and in order to prevent them from having a hurtful effect on the health of the operators, it is advisable to fit a pipe of platinum or glass, to the hole in the cover of the eggs. It has been proposed indeed that the eggs should be covered with heads, connected with receivers, in which the sulphuric acid might be condensed.

The silver being dissolved, the solution is poured out of the platinum eggs into stone ware pans, and water is added so as to reduce its density to 15 or 20 deg. of Baumé's hydrometer, or so that a bottle holding a pound avoirdupois of water, shall hold about 18 oz. or 18 oz. and a half of the solution. The solution is then left for some time to settle, and being carefully poured off the brown powder, which is in fact the gold con-

tained in the silver; slips of copper are added, and the silver which is separated by the copper is carefully washed.

The silver obtained is melted in a crucible, and run into ingots.

The brown gold powder is mixed with a little saltpetre, and melted,—the use of the saltpetre is to separate any portions of copper that may be contained in it.

The blue solution that is left after the precipitation of the silver being a sulphate of copper, may be evaporated and crystallized, the fine large crystals picked out for sale, and the small dissolved again in water, and crystallized: or it may be employed in the preparation of various colours.

This is the process actually used at present by the French refiners, instead of the usual mode by aqua fortis.

Gold refined by Antimony.

The grain gold obtained in parting by aqua fortis still contains a small portion of silver, which injures its colour: hence in some mints, as in those of Holland, the gold is still farther refined with antimony. The gold is melted with twice its weight of sulphuret of antimony, in a covered crucible with a strong heat, and poured out into an ingot cone: the regulus is separated from the antimony that lies at the top, and is again melted a second and third time, if it was very impure, with a less quantity of sulphuret of antimony. The regulus is then melted in a large crucible, and the blast from a pair of bellows directed upon the surface, to evaporate the antimony; when the vapours cease to arise, a little refined nitre, or nitre and borax, is thrown upon the gold, and it is poured out. If the gold cracks under the rollers, it is melted again, and a little more nitre and borax flung upon it.

Gold refined by cementation.

Although the cementation of gold is more usually employed to extract the alloy of copper or silver from the surface of gold toys, and thus give them the appearance of a greater degree of fineness than they really possess; yet it is still used in some mints, as in that of Venice, and probably in that of Constantinople, and in those of other eastern countries.

The gold to be refined in this manner is rolled out into exceedingly thin plates, or granulated and laid in beds along with a mixture of four parts of brick dust, one of copperas calcined to redness, and one of salt, in a deep crucible, the bottom and top bed being of the cementing powder, the crucible is then

covered, the joints luted with clay, and exposed to a heat raised gradually, and finally kept up at a red heat for 18 or 24 hours. The crucible being then let to cool, the gold is separated from the cement and washed with hot water.

Gold Coin and Plate.

The gold coin of England is made of gold made standard by equal parts of silver and copper.

Gold is melted in the English mint in parcels of 90 to 105 Troy pounds, in foreign black lead pots, which are less liable to crack in the fire than the English. The air furnace is 14 inches square, and 20 inches deep, with the bars of the grate moveable. A stand cut from the bottom of an old pot, and about an inch and a half thick, is placed on the grate, and covered with coke dust. On this the melting pot is placed, and covered with another pot cut horizontally in half. A little lighted charcoal is placed on the grate, and about four inches deep, of coke on this; the draught up the chimney is totally stopt by a damper, so that the fire is brought on very gradually. When the coke is all alight, the furnace is filled with more coke up to the height of the wider ring of the covering pot, or muffle as it is called. As soon as the pot is thus brought to a bright red, the draught up the chimney is opened, and the pot charged with the gold, which takes about an hour to become melted. It is then stirred with a black lead rod previously heated to a bright red. A grate bar on each side of the pot stand is then drawn out, the fuel forced into the ash room, the pot taken out with vertical or melting furnace tongs, placed on the top of the furnace, then removed with horizontal or wind furnace tongs, and its charge poured into the ingot moulds, to form bars ten inches long, seven wide, and one thick. The pot is then returned to the furnace, the grate bars replaced, as also the fuel, and the pot re-charged. By proper care, a pot may be used eight or ten times in the course of a day.

The bars of gold do not require annealing to enable them to stand the action of the rollers.

The forge used by the Ceylonese goldsmiths deserves to be known, and may be useful to a practical chemist, when he wishes to use a small fire, and has no forge, but only a blow-pipe at hand. The Singalese forge is only a small low earthen pot full of chaff or saw-dust, on which he makes a little charcoal fire, which he excites with a small bamboo blow-pipe, about six inches long, the blast being directed through a short earthen pipe or nozzle, the end of which is placed at the bottom of the fire. It is astonishing what an intense fire, stronger than is required to melt gold or silver, can be brought up in a few minutes. The success probably depends on the bed of the fire being a combustile material, and a very bad conductor of heat.

Green Gold.

This shade of colour is obtained by melting 708 grains, or one ounce nine pennyweights and a half of pure gold, with 292 grains, or 12 pennyweights and four grains of pure silver.

Nitro muriatic solution of Gold.

For making this solution, four ounce measures of muriatic acid are mixed with one ounce measure of nitric acid, and after the acids have been mixed some hours, grain gold, as fine or pure gold is called by the refiners, is added, until no more is dissolved.

Nitro-muriatic solution of gold is used to make Cassius' purple precipitate, to gild metals by the rag, as also to gild steel.

Cassius' purple Precipitate.

This precipitate is made by dissolving a few grains of tin in muriatic acid; diluting the solution with a large quantity of distilled water, as a gallon to a dram measure of the solution, and dropping into the diluted liquid 20 or 30 drops of the nitro-muriatic solution of gold to each gallon. In the space of three or four days, a purple precipitate or slime will be found at the bottom of the vessel. The liquid being filtered, the precipitate is washed with water, and dried.

Cassius' purple precipitate is used to colour glass of a purple colour, when melted in open vessels: in close vessels it gives no colour.

QUICKSILVER OR QUIK,

Writers of chemical books usually call this metal quicksilver; but workmen frequently denote it by the name quik.

There are two kinds in the market.

Spanish quicksilver, packed in bladders, which are enclosed in small barrels, and these again in chests.

Austrian quicksilver, packed in cast-iron bottles, and imported partly through Holland, and partly from Trieste and Venice.

Both are very pure; workmen who use it can so readily discover the slightest addition of any other metal, by pouring it from one hand to the other, that it would be useless to offer any quik to them unless it were pure. The source of the impure quicksilver in the apothecaries' shops, is the purchase of the quik from the silvering tables of bankrupt or deceased

looking-glass makers, which is of course impregnated with tin, and sometimes lead and bismuth; this quicksilver is cheaper than the pure, and is thought by them good enough for making blue pill and blue ointment.

Dutch Vermilion.

There are two kinds of vermilion in the shops; the Chinese vermilion, or hartall, which is a sulphuret of arsenic, and the Dutch vermilion, which is a sulphuret of quicksilver.

The Dutch manufacture their vermilion, by grinding together 150 pounds of sulphur, and 1080 of quicksilver, and then heating the Æthiops mineral thus produced, in a cast-iron pot, 2 feet $\frac{1}{2}$ in diameter, and 1 foot deep. If proper precaution is taken, the Æthiops does not take fire, but merely elots together, and requires to be ground. Thirty or 40 pots, capable of holding 24 ounces of water each, are then filled in readiness with this Æthiops.

The subliming vessels are earthen bolt heads, coated two-thirds of their height with common fire lute, and hung in the iron rings, at the top of three pot furnaces, built in a stack under a hood or chimney, so that the fire has free access to the coated part; each sublimer has a flat iron plate, which covers the mouth of it occasionally. The fire being lighted in the evening, the sublimers are heated gradually to redness. A pot of Æthiops is then flung into each sublimer; the Æthiops instantly takes fire, and the flame rises four or six feet high; when the flame begins to diminish, the sublimer is covered for some time. By degrees, and in the course of 34 hours, the whole of the Æthiops is got into the sublimers, being 410 pounds into each.

The sublimers being thus charged, the fire is kept up, so that on taking off the cover every quarter or half hour, to stir the mass with an iron poker, the flame rises about three or four inches above the mouth of the sublimer. The sublimation usually takes 36 hours, and when the sublimers are taken out of the furnace, cooled, and broken, 400 pounds of vermilion are obtained from each.

Berzelius, who calls it *bi sulphuretum hydrargyri*, or Hg S^2 , makes the atomic weight 2,933,920. Dr. T. Thomson also considers it as Hg S^2 , but calls it *per sulphuret of quicksilver*, and its weight as 29,000.

Turpethum Minerale, or Queen's Yellow,

Vulgarly called, from the contracted manner in which druggists' bottles are labelled, turpeth mineral.

It is made by heating one pound of quicksilver, with six or seven pounds of oil of vitriol, to dryness, and then throwing this white mass into a large quan-

tity of hot water, by which means the deuto sulphate of quicksilver, as the white mass is called, is separated into sub deuto sulphate of quicksilver, or the turpethum minerale, which settles in the form of a beautiful yellow powder, and into acid deuto sulphate of quicksilver, which dissolves in the water, and every trace of which must be removed from the turpethum by plentiful washing.

The suffocating fumes of sulphurous acid, which are emitted in large quantity in this process, require it to be performed under a hood, through which a strong draught of air is made to pass.

To avoid this inconvenience, the quicksilver may be added to strong nitric acid, kept hot until the effervescence and red vapours of nitrous gas cease, but no longer. Glauber's salt, equal in weight to the quicksilver, is then to be dissolved in a large quantity of hot water, and the nitric solution of quicksilver poured into it; the liquid is then filtered, and the turpethum left on the filter washed.

Turpethum minerale forms the active ingredient in what is called *eye snuff*, for man or horse; and it is also used as a bright yellow colour.

According to Dr. T. Thomson, who calls it *neutral per sulphate of quicksilver*, it is $S::Hg$; and its atomic weight, of course, 32,000.

Nitric Solution of Quicksilver.

Nitric acid, diluted with three times its weight of water, slowly dissolves quicksilver, without any application of heat.

This cold solution mixes with pure water without any diminution of transparency; but if 4 gallons of water contain only one grain weight of muriatic acid, a drop or two of this nitric solution will produce a slight dull tinge. Or if four pounds of water contain only one grain weight of ammonia, a drop or two of the solution will produce a slight blackish yellow tinge.

This solution may also be used to discover phosphoric acid; the sediment thus produced is taken up again, by adding more phosphoric acid, or nitric acid, which is not the case with the sediment produced when muriatic acid is the cause.

Red Precipitate.

This is an oxide, or sub-nitrate of quicksilver, prepared by means of nitric acid; but although this oxide, if it may be so called, can be easily prepared for private use, there is considerable difficulty in giving it the peculiar scaly appearance of the Dutch red precipitate, which is probably all made at Idria.

The common process is to dissolve quicksilver in strong nitric acid, taking care to add no more quicksilver to the acid as soon as the red vapours cease. The solution is then evaporated to dryness; and the dry mass calcined in a broad shallow dish, until it no longer emits red vapours; but this has not the proper scaly appearance required in the market.

A process is given, which is said to give this marketable quality: six pounds of quicksilver are to be dissolved in ten pounds of aqua fortis, and the solution kept on warm sand for

two or three days. One half is then poured into a large retort or rather body, and distilled to dryness. The mass being taken out, is divided amongst six retorts, placed on a sand heat; the remaining half of the solution is also divided amongst them, and after some hours' digestion, the whole is distilled to dryness. The aqua fortis that comes over in these distillations is used in the next operation, adding about a quarter of fresh acid.

The dry masses thus obtained, are put into three retorts, placed in separate sand pots, and furnished with receivers, the fires are so managed, that in the first three hours some flowers should settle in the arch of the retorts; in the next three hours, they should be driven into the neck; and in the last three hours, the mass in the retorts should appear first yellow, then orange, and lastly vermilion red; the fires are then to be stopped, and when cool, the red precipitate, it is said, will have the proper scaly appearance.

As this scaly appearance is supposed to proceed from a very minute proportion of corrosive sublimate, diffused through the mass, some chemists have directed that the nitric acid it should be made with, should be distilled from a very small proportion of salt: namely, 1 Troy lb. of acid, from an apoth. dram of salt.

Fulminating Quicksilver.

This can only be prepared in small quantities, not exceeding an ounce at a time, on account of the danger of explosion.

100 grains, or 1 dram 2 scruples of quicksilver, are to be dissolved without heat in $1\frac{1}{2}$ ounce measure of nitric acid, the solution poured upon 2 ounce measures of spirit of wine, and heat applied until the liquid begins to effervesce. A white powder collects at the bottom of the flask, which is, without loss of time, to be put upon a filter, well washed with distilled water, and dried in a water or steam bath.

Mr. Wright says, many sportsmen give it a preference, as a priming for percussion guns, over the mixture of oxymuriate of potasse and sulphur, because it requires a harder blow to inflame it, and it is not liable to spontaneous explosion. It is suspected that it will wear the nipples in which the caps are placed, faster than the oxymuriatic priming, but this might be obviated by making the inner part of the nipple of platinum.

Corrosive Sublimate.

The theoretical chemists have given a number of new names to this salt, as *corrosive muriate of quicksilver*, *oxymuriate of quicksilver*, *muriate of oxidated quicksilver*, and still more lately, *deuto chloride of quicksilver*, and *deuto chlorure of quicksilver*.

This was first manufactured at Venice, and hence long called Venetian sublimate. They grind 400 pounds of copperas, calcined to redness, 200 of saltpetre, 200 of salt, 180 of quick-

silver, 50 of the residuum of some former operation, and also the impure sublimate, generally 20 pounds; of the last operation, moistening the whole with some of the acid that had distilled over on some former sublimation, and sublime it in glass bolt heads, covered with heads, and fitted with receivers, set in a sand heat, under which are several fire rooms.

Kunkel, in 1722, proposed to make corrosive sublimate by boiling two pounds of quicksilver in an equal weight of oil of vitriol, to dryness, and when the mass was cooled, to grind it with three pounds and a half of salt, and sublime as usual.

This process is that now used by the manufacturers:—50 pounds of quicksilver are put into a cast-iron pot or dish, along with 60 pounds of oil of vitriol, and the pot being set upon a furnace, or, which is still better, on account of the suffocating fumes, placed in the chamber of a reverberatory furnace. The mixture is gradually heated; until a sample of the thick white mass being taken out, and thrown into some pearl-ash water, turns of a clear yellow colour, without any admixture of blackness. The fire being then withdrawn, and the mass cooled, it is ground with 50 pounds of salt, and 10 pounds of black manganese, left for two or three days, dried with a gentle heat, then divided into several bolt heads, and sublimed on a sand heat.

There is considerable difficulty in managing the fire at the end, so as to procure all the corrosive sublimate, and yet have it in a solid cake, for the least excess of heat melts some of it, and it runs down.

When the sublimate is not for sale by wholesale, the method proposed by Homberg, in Mem. d l'Acad. for 1709, is to be preferred. He advises, that instead of being sublimed in bolt heads, it should be distilled with a very quick fire from a very low retort, having a short wide neck, into a large receiver; the greater part will come over in the form of fine white snow. He found, that in consequence of the newly condensed sublimate, being liquid, it was continually running down, and had got to be raised over again; so that it took 12 hours to sublime three pounds of sublimate in a bolt head; whereas, in a retort, six pounds came over in only two hours.

Corrosive sublimate is the *murias hydrargyricus*, of Berzelius, or $\text{Hg}'\text{M}'^2$, and its atomic weight, 3,416,900. Dr. T. Thomson calls it *per chloride of quicksilver*, or Cl Hg , and its weight 34,000.

Calomel.

This, which is the *sweet sublimate* of the old chemists, has received a number of names lately, as *mild muriate of quicksilver*, *muriate of quicksilver*, *muriate of oxydulated quick-*

silver; and of late, those of *proto chloride of quicksilver*, and *proto chlorure of quicksilver*.

The old process for preparing calomel, and which is still followed in general medical laboratories, is to grind quicksilver together, with an equal weight of corrosive sublimate, moistened with a small quantity of water, until they are thoroughly mixed, and then sublime the mass in bolt heads. As corrosive sublimate is a most violent poison, and calomel is used only as a medicine, and in modern practice more frequently than any other, the sublimed mass is powdered, and very carefully washed, with a large quantity of warm water; calomel being nearly totally insoluble in water.

The manufacturing chemists now use nearly the same process for calomel as for corrosive sublimate; using, however, only two-thirds the quantity of oil of vitriol in the preliminary process, and stopping as soon as the black colour struck by the proto sulphate of quicksilver, with sub carbonate of potasse water, is of a full black, and before it acquires a yellowish tinge. In the sublimatory part of the process, the black manganese is omitted, and a stronger fire used. The calomel obtained is ground to powder, well washed, and assayed with pure caustic potasse water, with which it strikes a deep black colour; whereas corrosive sublimate produces with the same water a reddish yellow.

Calomel, for medical purposes, ought to be in the state of the finest powder; and Mr. Howard, following the steps of Homberg, has effected this by chemical means in a manner superior to the mechanical division. This he performs by distilling the mixture for calomel in low retorts, into double necked, quilled receivers, kept filled with steam, the vapour of the calomel, being prevented from condensing in the arch or neck of the retort by the heat, no sooner meets the steam than it immediately becomes solid, and takes the form of an impalpable white powder: common powdered calomel is of a dead yellowish white.

Calomel is the *murias hydrargyrosus* of Berzelius, or $\text{Hg} \cdot \text{M}^2$, and its atomic weight, 2,974,250. Dr. T. Thomson calls it *proto chloride of quicksilver*, or Cl Hg^2 , and its weight 29,500.

Silvering for Looking Glasses.

Looking glasses are silvered by an extemporaneous amalgamation of tin and quicksilver. Tin foil is placed on the back of the glass, and some quicksilver is poured upon it, and spread over the surface with a hare's foot. Another glass is then slid over the tin, to drive off part of the quicksilver; and paper and a board being laid on the tin, it is strongly pressed with a

number of weights, to expel, by degrees, the superfluous quicksilver, and leave only a crystallized amalgam on the back of the glass.

Silvering for Globes.

This amalgam is made by dissolving one pound of tin glass or bismuth, in four pounds of quicksilver. The globes to be silvered are thoroughly cleaned on the inside, and warmed, then the above amalgam being heated, so as to be perfectly liquid, is poured in by a paper funnel, and the globe inclined in various directions, that as the amalgam crystallizes by cooling, it may adhere to all parts of the globe; the superfluous amalgam is then poured out.

SPELTER OR ZINC.

Of this there are several kinds in the market.

German spelter, or *spiauter*—it is not esteemed pure.

Tutenag, *calain*, or *Indian zinc*—imported in thin rectangular plates, 8 or 9 inches long, $5\frac{1}{2}$ wide, and $\frac{1}{4}$ inch thick: it is very brittle. It is esteemed very pure.

English, or *Bristol zinc*—in blocks, ingots, and bars of different weights.

Rolled, or *sheet zinc*—made by rolling English zinc.

Zinc wire, and *zinc turnings*, are also to be obtained at the metal warehouses.

Spelter was originally obtained as a secondary product in the smelting of the lead ore found near Goslar, and as it dropped in the form of nails, the metal has also received this name—*zinken*.

What spelter is, or what uses are already made of it, Mr. Mason, in the Philosophical Transactions, for 1747, professes not to know; but he believes it was never yet applied to so large a work as the cylinder of a fire engine, till Mr. Ford, of Coalbrooke Dale, in Shropshire, did it with success. It ran easier and cast as true as brass, and bored full as well, or better, when it had been warmed a little. While cold, it is as brittle as glass; but the warmth of his hand soon made it so pliant, that he could wrap a shaving of it round his finger like a bit of paper. This metal never rusts; and therefore works better than iron, the rust of which, or the least intermission of working, resists the motion of the piston.

Extraction of Spelter from its Ores.

The process for obtaining spelter or zinc, by distillation, is said to have been introduced from China into England, where the manufactory was first established at Bristol.

Fig. 206, represents the plan of the zinc furnace, and fig. 207, the vertical section of the same. In these figures, *a*, is the grate of the furnace, supporting the coals used for fuel, and *b*, is the ash room. *c*, *d*, *e*, *f*, *g*, *h*, are six arches; under the floor of the fire room, which is filled with six cast-iron crucibles, *i*, to receive the calcined ore that is to be distilled. Fig. 208, is a vertical section on a scale of twice the size of one of these crucibles; and fig. 208*,

is a cast-iron pipe, that is fitted to the bottom of these crucibles. *K, L*, are six small chimneys, furnished with registers, *m*, that regulate the draught of air through the furnace. *N*, are six tubs, filled with water, into which the spelter that is distilled drops, and is congealed.

The ore, if very pure, is only stamped, but if mixed with earthy or stony matters, it is stamped in a current of water, and washed. The ore is then roasted in the chamber of a reverberatory furnace, about 10 cwt. at a time, the fuel is coal, and the operation is continued for about four or five hours. After this, the roasted ore is mixed with one-seventh of its weight of charcoal dust, and the crucibles are charged with the mixture; for this purpose, the cover is taken off, the mouth of the pipe that passes through its bottom, closed with a stopper of clay, and the charge introduced by the opening in the roof of the furnace over the crucible, which is afterwards covered, and the joints luted, the clay stopper to the pipe being previously removed.

Fire is then applied, and when the brown blaze that appears at the mouth of the pipe, owing to the combustion of the cadmium, contained in the ore, which, as the most volatile of the two metals, rises first, is succeeded by a blue blaze, indicating the distillation of the spelter itself; another cast-iron pipe, reaching nearly to the surface of the water, is fitted to the end of that which is fixed in the crucible; the burning of the zinc being thus prevented, it falls in drops into the tubs of water. The whole operation, including the charging and emptying of the crucibles, when the furnace is cool, generally takes up five days. The zinc obtained, is afterwards melted in an iron pot, its surface being kept covered with charcoal dust, to prevent oxidation; and ladled out into iron moulds.

Ten cwt. of ore generally produces 4 cwt. of spelter or zinc, with the expense of 115 cubic feet of pit coal. The annual produce is about 4000 cwt.

Blende may also be distilled in this manner for spelter; but it has been found more advantageous to use it in the manufacture of brass.

Several patents have been taken out for improving this process, particularly in respect to the form of the pipe in the crucible; but the old method is still preferred by the manufacturers in England.

Mr. Dillinger's improvements in this process have, however, spread considerably in Germany, and the neighbouring countries.

Fig. 209, represents partly the section, and partly the elevation of these furnaces; and fig. 210, the plan of four of them, as they are connected together. *A, b, c, d*, are the fire rooms of these furnaces, with their ash rooms; grates, or pierced vaults, and doors. *E, f, g, h*, are the charging doors of the

chambers of these reverberatories, upon the floor, *m*, of which are disposed a great number of baked earthen long pots, about five feet long, and six inches wide, closed at top, open at bottom, and filled with the prepared zinc ore. *I*, are side openings, by which the flame that had passed into the chamber, through the openings, *k*, vents itself into the hollow space between the furnaces, and from thence into the chimney, *t*, which serves for the whole set. *M*, *n*, are earthen pipes, open at both ends, and shaped like the capital of a column, the pipes are hung quite close together, in a grating of iron bars that form the real floor of the chamber; but as the square heads of these pipes overlap the bars, and meet together, they form the floor that is actually exposed to the heat. A groove, in the edge of these pipes, *m*, receives the open end of the long pots, *p*, and the prepared ore is prevented from falling out, by some large pieces of charcoal which are stuck in the mouth of the long pots. *R*, are sheets of rolled iron, placed below the floors of the chamber to receive the drops of zinc that distil down from the short pipes, *m*, *n*. *S*, are sheets of rolled iron, hung before the vault under the floor of the chamber, to hinder a draught of air on the zinc as it drops from the pipes, as that draught would cause the zinc to take fire. *T*, is the chimney of the whole stack of four furnaces.

Each of these furnaces are, according to the plan, made for 160 pots, in 10 rows of 16 pots each, but only 84 of them charged with ore, are put into the furnace, along with a sufficient number of unbaked empty pots, to supply the place of those that break in the operation, which is usually about 28 or 30.

The 64 pots of the first four rows next the fire room, are charged with a mixture of 14 cubic feet, or 1820 pounds of stamped and roasted calamine, 36 cubic feet, or 504 pounds of bruised charcoal, passed through a sieve whose meshes are only $\frac{1}{2}$ inch wide, 36 pounds of common salt, and 4 cubic feet, or 280 pounds of water containing 3 pounds of potash in solution. Only 20 pots are placed in the two next rows, the spaces of 12 pots being left empty. These pots are charged with a mixture of four cubic feet, or 520 pounds of stamped and roasted calamine, 16 cubic feet, or 224 pounds of small pieces of charcoal, pass through a sieve whose meshes are $\frac{1}{2}$ inch wide, 16 pounds of common salt, and one cubic foot, or 70 pounds of water holding $\frac{3}{4}$ pound of potash in solution. As each of the pots hold 771 cubic inches, or about 20 or 21 pounds of the mixture, the above quantity is the charge for two of these furnaces, which are usually heated at once, while the other pair are cooling.

The furnaces are heated with beech billets, and the firing, which lasts from 30 to 36 hours, consumes about 72 cubic yards of wood. The 2340 pounds of roasted calamine in the above charge, produces about 800 pounds of raw spelter, which is received on the sheets of iron, and being afterwards melted to be cast into ingots, yields about 700 pounds of pure zinc, and about 150 pounds of oxide, which is mixed with the calamine in the next operation.

Fig. 207

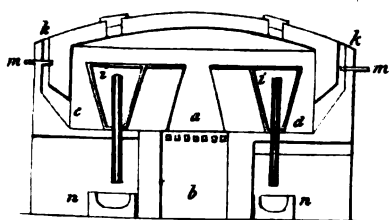


Fig. 208

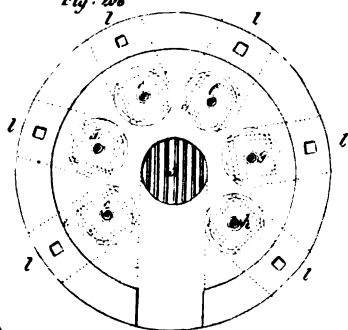


Fig. 209

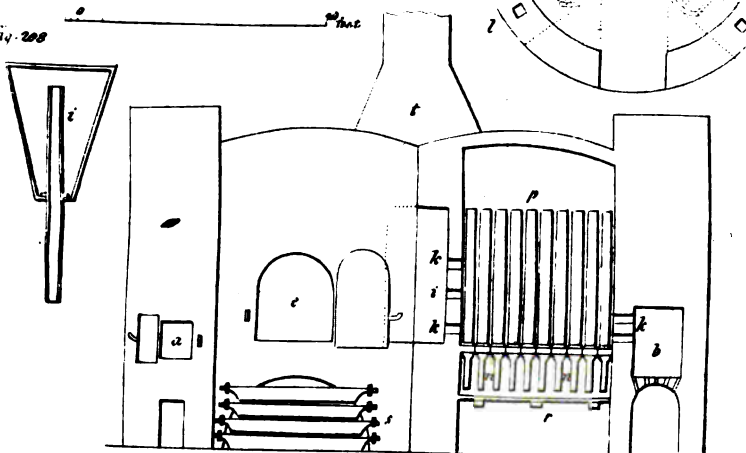
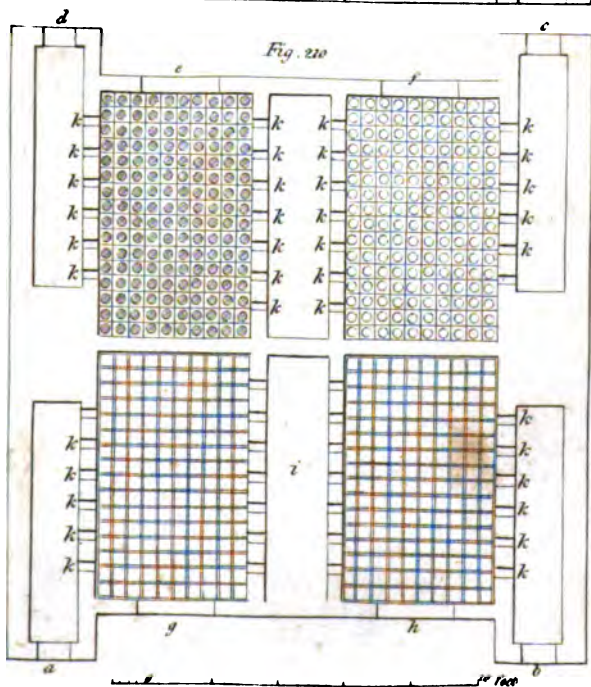


Fig. 210





The annual production of zinc from the mines in Carinthia, is 3000 cwt.

The same kind of furnaces are used in Poland and Silesia; but as the fuel employed there is pit coal, some slight alterations are made in their construction. In Silesia, the pots are two feet wide in their upper parts, which is, in fact, their bottom.

At Liege, calamine is distilled for zinc in another manner. Earthen pipes are placed horizontally across the furnace, and open at both ends. They are charged at their widest end, which is afterwards stopped with clay, with a mixture of 100 pounds of stamped and roasted calamine, 15 of ground charcoal, and five each of common salt and argol. An iron pipe, slightly bent downwards, is luted to the narrow end of the distilling pipes, and is kept constantly cool by wet rags, to condense the vapours; and thus the zinc is made to fall in drops into water. The furnace is heated with coal, and as the distilling vessels cease to yield the metal, the wide end is opened, the charge withdrawn, and a fresh charge introduced, without withdrawing, or even diminishing the fire.

White Vitriol.

This is obtained, as a secondary product, in the metallurgic treatment of the lead ore of Rammelsberg, near Goslar, which contains calamine mixed with it.

When the ore is roasted, it is thrown, while yet hot, into large troughs filled with water; which is afterwards drawn off, evaporated in leaden boilers, and let off into wooden cisterns, where it remains several weeks. The crystals thus obtained are melted in a copper; the milky liquor into which they are resolved is scummed, ladled out into square wooden boxes, and stirred with a wooden spatula till it is quite cold. After some time it becomes solid, but of a loose and spongy texture, like loaf sugar.

If the water from the ore troughs is judged to contain a notable quantity of iron and copper, some zinc is added in the boiling, to separate these metals.

White vitriol is principally used in oil painting, to cause the oil to dry quickly.

According to Dr. T. Thomson, its composition is $\text{Zn} \cdot 8 \cdot + 3 \text{H}$, and its atomic weight, 13,625.

Sulphate of Zinc.

This is manufactured by dissolving zinc in oil of vitriol, weakened by the addition of six or eight times as much water, evaporating the solution to a pellicle, and setting it by to crystallize.

The crystals dissolved in water, is a common wash for sore or weak eyes, but they are useless as a dryer to oil paint.

Berzelius calls it *sulphas zincicus cum aqua*, or $\text{Zn} : \text{S} :: 2 + 10 \text{ Aq.}$ and its atomic weight, 3,133,120. Dr. T. Thomson makes it $\text{Zn} : \text{S} :: 1 + 7 \text{ Aq.}$ and its weight, 18,125.

Zinc White, or Carbonate of Zinc,

Is manufactured by pouring into a solution of zinc, in sulphuric acid, a solution of carbonate of ammonia, as long as any sediment falls, which is to be washed and dried.

It is used for a paint, but does not cover so well as white lead.

BISMUTH, OR TIN GLASS.

Bismuth, as it is called in chemical books, is usually known by the name of tin glass among workmen; evidently a corruption of the common French name, *étain de glace*, tin for silvering glass; as the name, bismuth, is of the weiss muth, or white mother of silver, of the German miners.

When pure, no metal is so easily obtained in the form of crystals, which are small cubes grouped together. The bismuth is to be melted in a covered crucible, and a good heat given to get rid of any arsenic it may contain. It is then to be poured out into a warmed black melting pot, having a hole in its side closely stopped with a wooden peg. As soon as the bismuth has set at top, the peg is to be withdrawn, that the liquid part of the metal may run out. On turning out the solid crust of metal, it will generally be found finely crystallized on its under surface.

Bismuth, like cast iron, expands as it sets, and even retains this property when mixed with other metals; hence it is used by the letter founders in their best type metal, to obtain a sharp and clear face to their letters.

Extraction of Bismuth from its Ores.

Bismuth is a metal very easily melted, and the only ores smelted want merely the application of heat to run the metal from the stone in which it is enveloped. Hence bismuth is sometimes obtained by merely lighting a wood fire upon a hearth of rammed clay, and throwing the ore into the fire. When the fire goes out, the bismuth is separated from the ashes by washing them in water, remelted in an iron pot, and poured into ingot moulds.

Bismuth is also obtained by the same apparatus of double pots, as crude antimony.

The greatest part of bismuth used in Europe, is obtained at Schneeberg, in Saxony, by the following apparatus:—Five pipes of cast iron, five feet long, and eight inches wide, are placed side by side, and with a very gentle slope, in the upper part of a fire room, which is covered with an arch, having a

few vent holes, serving as chimneys. The whole furnace is 13 feet long, 6 feet high, and 4 feet $7\frac{1}{2}$ wide, so that the ends of the pipes stick out about three inches on each side. One of these ends used for charging, is closed when necessary, with an iron cover; the other end is stopped up constantly with an earthenware stopple, having a notch in it to allow the metal as it melts to run out. A cast-iron pot, set on a chafing dish, is placed under this end of each pipe to receive the bismuth as it flows, and keep it melted under a covering of charcoal dust. Tubs of water are placed under the other end of the pipes, into which the charge when drawn out of the pipes is thrown.

The fire being lighted, and continued for three or four hours, about half a cwt. of ore, broken into pieces the size of a nut, is charged into each. In about 10 minutes the metal begins to run out at the other, and this continues for half an hour. The charge is then withdrawn, and a new charge introduced. When the iron receiving pots are nearly full, the metal is laded out into other pots, where the charcoal dust is scummed off its surface, and it is left to cool; thus forming cakes of from 25 to 50 pounds.

Twenty cwt. of the ore at Schneeberg, yields in eight hours about $1\frac{1}{2}$ cwt. of bismuth, and there are consumed about 63 cubic feet of wood.

Bismuth is also obtained in the same manner from the speiss of the smalt works, when the cobalt ores used in them are mixed with bismuth.

Fusible Metal, or Metallic Pencils.

When bismuth is added to a mixture of lead and tin, it causes them to melt with a very low degree of heat. Equal quantities of these three metals may be melted in a bit of paper over a candle, without burning it; but the mixture that melts with the smallest heat, is that of 8 oz. of bismuth, 5 oz. of lead, and 3 oz. of tin, which melts at 202 deg. Fahrenheit. Hence toy spoons are made of them, which being given to children to stir very hot tea, melt while they are using them. Parkes has proposed the use of these compounds of lead and tin, with or without bismuth, in certain proportions, to form metallic baths, in which cutlery may be immersed for the purpose of tempering it always at the same precise temperature.

Another use of this fusible alloy, as it is called, is for making metallic pencils to write upon paper, prepared by having burnt hartshorn well rubbed upon it. The marks are as fine as those of black lead pencil, and not so easily rubbed out. Memorandum books of this kind are very convenient, being equally

ready for use with black lead pencils, and yet as permanent as ink.

REGULUS OF ANTIMONY, OR REGULUS.

This is more usually called by the simple name of *regulus* only, among artisans.

The manufactory of regulus of antimony, on a large scale, is carried on at Riom and Clermont, in Auvergne. The sulphuret of antimony, called common antimony, is first roasted in a reverberatory furnace until it forms a gray oxide; a cwt. of this is afterwards mixed with 8 or 10 pounds of argol, and the mixture smelted in large melting pots placed in a wind furnace. As regulus of antimony is very fusible, the furnace requires no chimney.

Lampadius proposes to smelt the gray oxide thus obtained, nearly in the same manner as lead is smelted from litharge. But instead of bellows, he introduces the air by three openings towards the bottom of the furnace; and procures a sufficient heat by adding a chimney at the top of the furnace; thus changing it into a wind furnace.

About 1788, the manufactory was attempted at Glendinning, in Scotland, by smelting the antimony with a proportion of iron to abstract the iron, as in making the martial regulus of antimony of the apothecaries. The same process was also adopted at Vienne, in France; but both of these manufactories have been stopped; partly on account of the small demand for this metal.

Regulus is added in making a few compound metals, to give hardness to the mixture; as in the best pewter, in some type metal, and in casting leaden medallions.

Common Antimony.

Common antimony, called by theorists sulphuret of antimony, is obtained from the ore of the same nature by merely running it free from the stony matrix. As it is very easily melted, it is only necessary to put the ore into a crucible or other pot, having holes bored in its bottom, to insert this pot in the mouth of another, and apply heat to the upper pot to melt the ore, and thus cause it to run into the lower pot, which is kept cool.

Formerly, a number of the lower pots were sunk in the ground, and the upper pots being luted to them, a covered heap of wood placed upon the whole, was set on fire, and when the wood was burned out the pots were removed, and the crude antimony found in the lower pots taken out for sale;

while the matrix which is much less fusible remained in the upper pots.

As a great part of the heat is wasted in this disposition of the pots, unless charcoal be made at the same time, a furnace has been used to heat the pots.

Fig. 211, represents the plan of this furnace, as built at Anglebas, in Puy de Dôme; and fig. 212 its vertical section, in the direction, *t, u*, in the plan. *A*, is the opening into the fire room, *b*, and is closed by an iron door. *B*, is the grate, which is moveable, and is also the space in which the workman stands while he ranges the pots on the bank. *C, d, e*, is a bank of brick work surrounding the fire, so that the entire diameter of the internal part of the furnace is about 10 feet; this bank is bound together by two strong iron hoops. *F, g, h, i*, are small flues in the sides and crown of the furnace, conducting the burned air and smoke into *k*, the chimney of the furnace, which is very short. This chimney is, however, topped by another, about 17 feet high, built of bricks, upon a strong plate of iron, supported at each of the four corners by an iron bar, attached to the roof of the shed; by turning the nuts of the screws, this moveable chimney is adjusted to the chimney of the furnace, and the joint closed with clay.

This furnace holds 75 sets of pots. The upper pots are 19 inches high, 11 inches wide at top, and 8 at bottom, in which they have five holes, about $\frac{1}{2}$ inch in diameter; these pots are charged with 40 pounds of ore, $\frac{1}{3}$ rich ore placed at bottom, $\frac{1}{3}$ ore mixed with the matrix in the middle, and $\frac{1}{3}$ poor ore placed at top. The lower, or receiving pots, are the middle sections of a sphere, 10 inches in diameter, cut off at top and bottom so as to stand 9 inches high; and the mouth at bottom to be 8 inches wide. The placing of the pots takes three men three hours' labour.

The firing, which is given by beech wood, is weak for the first hour, then gradually increased for three hours, when some fagots of broom, are thrown in, to give a sudden and flaming fire, which is gradually slacked for two hours. This firing consumes about 15 or 16 cubic feet of beech wood, and 20 broom fagots. The operation, including the cooling of the furnace, takes up a day, or a day and a half; and 300 cwt. of ore produce about 15 cwt. of smelted antimony. One half of the pots are usually broken.

To save this expense of pots, it has been proposed to run the ore in iron pipes, lined with clay, and placed across the furnace, as in smelting bismuth ore. It has also been attempted to smelt the ore on the bed of a reverberatory furnace, the bed being made of clay, with a slope towards the eye, which was left open so that the smelted metal might run out as soon as it was rendered fluid, and be received in pots for sale. But neither of these methods have prevailed.

Common antimony is used to make the regulus and glass of antimony. According to Berzelius, who calls it *sulphuretum stibi*, it is Sb S²; its atomic

weight is 2,216,380, and it contains 7277 parts of regulus in 10,000. Dr. T. Thomson makes it Sb 8, and its atomic weight 7500.

Glass of Antimony.

This is manufactured by grinding common antimony to powder, calcining it in a very gentle heat, till it becomes a light gray oxide, and does not emit fumes in a red heat. If any clots are formed by the heat being too great, they must be taken out, ground down, and again returned to the furnace.

The oxide thus obtained, is to be put into a crucible, and melted in a brisk fire, without any addition; it generally forms a brown transparent glass. If the antimony has been calcined too much, it is rather hard to melt: some chemists in this case, throw a little common antimony into the crucible; but this addition gives the glass a darker colour than if pure.

It is used to prepare tartar emetic.

Some years ago a druggist, being distressed and in the King's Bench Prison, made a quantity of glass of lead, coloured it to imitate glass of antimony, and sold it for that article before the fraud was discovered. Some of this glass still remains in the apothecaries' shops, to whom it was sold.

Glass of antimony varies in its ingredients, according to the quantity of silica that it extracts from the crucible.

Crocus Metallorum.

This is made by calcining common antimony until it acquires only a dull gray colour, and then melting it in a crucible.

It is used to make emetic tartar.

Emetic Tartar.

The old process for making this double salt, was to mix one pound of crocus metallorum with a pound of cream of tartar, boil the mixed powder in a gallon of water for an hour or two, filter, evaporate to a pellicle, and set it by to crystallize; the mother water is again evaporated, until it ceases to yield crystals.

But since glass of antimony has been manufactured on a large scale, and thus may be bought cheaper than the crocus can be made, it has been used in preference.

A number of other processes, some of them very complicated, have been given for making this salt; but their use has been confined to their inventors, as all the wholesale makers of emetic tartar use one or other of the above methods.

Emetic tartar is at present the most generally used antimonial medicine, and its exhibition may be managed so as to produce either sweating, purging, or vomiting.

Berzelius calls this salt *tartras kalico stibicus*, or $3 K: T-2 Aq^3 + 4 Sb: T-3 Aq^3$, and thus makes its atomic weight 28,235,830. Dr. T. Thomson thinks it should be called *ditartrate of potash and antimony*, considers its composition to

be $T-Sb+T-K \cdot Sb+2 Aq.$ and its weight, 44,250. Gay Lussac thinks the cream of tartar performs in this and similar salts, the part of a simple acid.

Kermes Mineral.

The best process for making this medical article, much used by the Continental physicians, is to boil one pound of common antimony, 22 pounds $\frac{1}{2}$ of sub carbonate of potasse, and 20 gallons of water in an iron pot, filtering the liquor while hot into earthen pans, and letting it cool slowly for 24 hours; the Kermes mineral is deposited in form of a deep purple brown velvety powder.

The supernatant liquor, on the addition of any acid, yields an orange sediment called *golden sulphur of antimony*; which the calico printers use as a yellow colour. The supernatant liquor is evaporated and crystallized, the crystals dissolved in water, the solution thickened with paste or gum, and thus printed; the cloth is then dried, and passed through a very weak acid liquor, which separates the golden sulphur, and fixes it on the cloth. [For a more economical and particular account of the sulphuret of antimony with soda, or the orange crystals, of the calico printer, see the sequel to the articles on the manufacture of bleaching liquor in this work.]

REGULUS OF COBALT.

Called by the theoretical chemists simply, *cobalt*, which is properly the name of the ore from which this metal is extracted.

Regulus of cobalt is not smelted, but the ores are treated for the oxide of that metal, which is a rich blue colour.

Zaffre.

Zaffre is prepared from the ores of cobalt that contain sulphur and arsenic, and which are roasted 3 or 5 cwt. at a time, in a reverberatory furnace, with chambers attached to receive the arsenic. The ore generally loses rather more than one-third of its weight, so that a cwt. yields about 68 pounds of zaffre, or zafflor.

The ores that contain much nickel are not fit for the preparation of zaffre, as the oxide of nickel would injure the beauty of the blue colour, or smalts; for the making of which, zaffre is manufactured.

Inferior kinds of zaffre are made by mixing this oxide, previously stamped and sifted to a fine powder, along with calcined flints, or quartz, also ground in various proportions, according to the use for which it is intended, moistening the

whole with water, and packing it tight in casks, where it hardens to a stone.

A very fine zaffre, or China blue, is obtained from the arsenical and gray cobalt ore, found in Cornwall, by boiling the powdered ore in nitric acid, which converts the arsenic into arsenical acid, and unites it with the different metals contained in the ore. The solution being diluted with a large quantity of water, purified pearl-ash water is then added in small portions to the diluted solution, and on the addition of each portion the liquid is well stirred, left to settle, and the clear poured off. This is repeated until the solution becomes of a rose colour, which shows that it contains only the arseniate of cobalt. The pearl-ash water is then added in larger quantity than is necessary to throw down all it contains, and the solution is boiled for a few minutes. Being then left to settle, the liquid is filtered, the oxide of cobalt left on the filter washed with boiling water, and dried. This oxide is then melted with felspar and a little potash, and thus yields a beautiful zaffre for painting China ware.

Another method is to grind the ore, mix it with two or three times its weight of China ware grossly powdered, and heat it very strongly. The whole is then put into three or four parts of nitric acid, diluted with an equal weight of water. The clear solution is poured off, evaporated gently to a syrupy consistency, diluted afresh with water, left to settle, poured off clear from the arsenic that is separated, and then the pearl-ash water is added by small portions, and the operation finished as in the former process.

Zaffre is used for making smalts, and for painting on the best kinds of pottery. The common zaffre is very cheap, but the best kind sells in the potteries for two guineas by the pound. It is also used to make cobalt.

Smalt, or Powder Blue.

Smalt is a glass, coloured with oxide of cobalt.

The natural oxides of cobalt are merely stamped, and very carefully washed. The other ores of cobalt are roasted and made into zaffre.

The basis of the glass is quartz, several cwt. of which are made into a heap with wood, and burned for 24 or 36 hours. It is then stamped in water, calcined in a reverberatory furnace, and sifted. The potash is carefully prepared, calcined, and kept dry.

A number of assays are made with these ingredients, to which are sometimes added white arsenic, black arsenic, and

the glass obtained by a preceding operation. The blue glass resulting from these assays, is ground, washed, and the colour compared with that of specimens kept as standards of the proper quality.

The furnace used is similar to that for making flint glass: in some places it is square, in others round. It generally contains eight pots, nearly cylindrical, two feet high, and as many wide. In Hesse, the pots have an opening on the side even with the bottom, and there is, besides, the usual working hole—another in the walls of the furnace, to allow the workman to close or unstop this hole in the pot. When the melting pots are new, they are spread over on the inside with powdered blue glass, before they are charged, in order to varnish them.

In general, for the best smalt, two parts of oxide of cobalt are melted with one of powdered quartz; and for the inferior smalt, with three parts of quartz. The calcined potash is used in nearly the same quantity as the quartz, and there is added one-sixth or one-eighth of the glass obtained in a former operation.

The furnace being heated, a cwt. of materials is charged by a peel into each pot, and this charge is usually melted in eight hours; for the last three hours it is stirred several times. When the glass sticks to the rod, and can be drawn into threads, the hole in the bottom of the pot is opened, and the speiss, or metallic matter that has settled at the bottom, is let to run out. After which, the glass itself is ladled out of the pots, and flung into a trough having a current of cold water running through it. In some manufactories, the speiss is not run off; but when rather more than half the glass has been ladled out, the workman lets any speiss he may take up in the ladle settle, and drops it into an iron basin.

When the pots are thus emptied, they are charged afresh, and thus 24 cwt. of materials are usually melted in the course of 24 hours, and there are consumed about 2016 cubic feet of very dry resinous wood. The produce is generally 19 cwt. of blue glass, and $\frac{1}{2}$ cwt. of speiss. The furnace is generally kept in continual use for 18 or 20 weeks.

When the speiss is rich in cobalt, it is used again. For this purpose, if it contains much bismuth, this is sweated out of it by the usual process for smelting bismuth; and then the speiss is stamped, screened, roasted, in a reverberatory furnace; again screened, and used as the other oxides of cobalt.

The blue glass thus obtained is first stamped, then sifted, and ground with water, 2 or 3 cwt. at a time, between granite stones. After some hours' grinding, the water and ground smalt is let to run into large tubs, where in a few minutes that part

of the powdered glass which is the best coloured, by being richest in oxide of cobalt, settles, and is sold under the name of *strewing smalt*. The other part is ground over again with water, and run into other tubs, where it is allowed to settle for about an hour; the glass that settles in these tubs, are sold by the name of *farbe*, or colour. The water is run off into other tubs, where it stands until quite clear; the smalt collected in these is called *eschel*, or ashes.

All of these sediments are washed over again, sorted into various qualities, and dried on slabs, either in a stove, or in sheds, with a free current of air. The cakes thus produced are crushed, either between cylinders, or by rakes, turned by water, or by ordinary mill stones; or lastly, between two planks moved contrary ways. After which, they are sifted or bolted. 100 cwt. of blue glass yields about 60 cwt. of colour, or 70 cwt. of ashes.

The strewing smalt is used in painting, and the others in tinging linen and paper of a blueish colour.

Speiss.

Speiss is a secondary product obtained in making smalt, separating from the glass during its fusion, and settling at the bottom of the pots.

It is a mixture of cobalt, nickel, iron, arsenic, bismuth, to which is sometimes added silver.

When it is rich in cobalt, it is used over again in the making of zaffre: and when rich in bismuth, it is used to obtain that metal.

Speiss is also the material from whence the experimental chemists generally obtain nickel.

PLATINUM.

This metal, which in the state it is usually obtained, alloyed with palladium and rhodium, joins the hardness of iron to the resistance of most chemical agents possessed by gold, is lately come into much use.

It is obtained from the ore brought from Spanish America, by the name of platina, the diminutive of plata, silver; and which is a kind of metallic sand. The platina is dissolved by the help of heat, in eight times its weight of a mixture of two parts of muriatic acid, at 22 deg. Baumé, and one of nitric acid, at 34 deg. Baumé. When the acid ceases to act, it is to be decanted, and fresh acid poured on the residuum, until all is taken up that the acid will dissolve, which generally requires

four parcels of the acid. By this means, the iridium and osmium in platina is left in the residuum.

The acid solution is then evaporated until it crystallizes upon cooling, in order to drive off the excess of acid, and diluted with 10 times its weight of water. A solution of sal ammoniac, made as strong as possible, is poured into the solution of the platina, in a quantity beyond that necessary to throw down, all the sediment it will yield. This sediment, which is an ammonia-muriate of platinum, is thrown upon a filter and well washed.

Platinum may be obtained directly from this ammonia muriate, by putting it into a crucible, and exposing it to the utmost degree of heat the chemist can command, observing to press down the mass with a button-headed iron rod, as the salt assumes the metallic form. When completely reduced, the regulus must be taken out of the crucible, and carefully forged; returning it frequently into the fire.

Another method, is to reduce the ammonia muriate by heat alone, without compression, and to melt the spongy mass of platinum alloyed with palladium and osmium thus obtained, with one-eighth its weight of black arsenic, and casting it to thin plates, or small rods. This compound metal is then repeatedly heated and forged, until the arsenic is driven away.

Willis found, that platina might sometimes be melted upon a bed of charcoal in a crucible; and M. Boussingault has lately found that platinum always melts in a blast furnace, if the crucible is lined inside with a mixture of clay and charcoal. He thinks this fusion is owing to the admixture thus produced, of silicon with the platinum.

Platinum may be melted in small quantities not exceeding two ounces, by the blast of the oxy-hydrogen blow-pipe, and even kept in fusion for some time.

Platinum is used for crucibles, evaporating dishes, and even alembics: it resists most of the acids, but is acted upon by caustic potasse, and several neutral salts. It may be welded like iron, and the proper solder for it is gold.

The solution of platina is used as a test to distinguish water containing potasse from that containing soda.

The concentration of oil of vitriol is now generally performed in platina stills, with leaden heads. Mr. Parkes had a still of this kind which held 35 gallons, and cost 300 guineas.

BLACK ARSENIC.

Black arsenic is the proper commercial name of the metal simply called *arsenic*, by theorists, and is manufactured by

distilling powdery white arsenic along with a little charcoal dust, and some iron filings and lime, so that if any sulphur is contained in the white arsenic, it may be hindered from rising. Arsenical pyrites, ground fine, is also used, and seems preferable.

The apparatus is the same as for red arsenic; only a sheet of iron, rolled up like a cylinder, is used as an adapter. When the apparatus is cooled, this iron adapter is unluted, and being unrolled, the black arsenic is found sublimed upon it in brilliant crystals, which soon grow black in the air.

In the neck of the receivers there is found a mass composed of black arsenic and white arsenic, which is sometimes sold by the name of *flie gen stein*, *fly stone*; but is more generally used in the next process, along with the powdery black arsenic found in the receivers.

White Arsenic.

White arsenic, in a powdery form, is obtained as a secondary product in the chambers attached to the furnaces used for smelting lead and tin ores, and in several other metallurgical processes. Arsenical pyrites are also roasted expressly for the purpose in reverberatory furnaces, with chambers attached.

As white arsenic is in this form very dangerous for carriage, on account of its poisonous quality, it is reduced to a glassy form by sublimation in large iron matrasses, formed of several pieces luted together.

Two of these matrasses are usually heated over one fire. The furnace is about 12 feet long, 6 wide, and 4 high; the two cast-iron pots which are set in this furnace, and serve as the bottom of the matrass, are two feet wide, and as many deep, hanging loose in the furnace by a flange round their mouth. Each of these iron pots are charged with 3 cwt. $\frac{1}{2}$ of powdery white arsenic, and then covered with a head made either of cast or hammered iron. These heads are cylindrical, four feet high, as wide as the pots, and contracted at top into a cone, a foot high, to which is adjusted a long pipe of sheet iron, a few inches wide, and ending in a chamber built over the furnace, and having a chimney at one end.

The joints between the pot and the head being luted with clay, mixed with blood and hair, the fire lighted and kept up for 12 hours, after which the apparatus is left till the morrow to cool, when the head being taken off, the glassy white arsenic sublimed in it is knocked off and sorted; the whitest parts are packed in barrels for sale, and the impure parts, as well as

that left in the pot, reserved for another sublimation. Each pot produces about 3 cwt. of glassy white arsenic, and the heating of the two pots consumes about 90 pounds of pit coal.

In some workshops, the heads put over the pots are open at top, the pots are not charged, but when they are red hot, a few pounds of powdery white arsenic are flung in at the top of the head, the opening of which is then closed with a tile; and this is repeated at short intervals. This method exposes the workmen too much to the noxious vapours.

If the powdery white arsenic contains any sulphur, a little potash is mixed with it, to hinder the sulphur from rising.

Red Arsenic, or Realgar.

Red arsenic, or realgar, is manufactured by distilling a mixture of arsenical pyrites with iron pyrites, or of powdery white arsenic with rough brimstone.

The distillation is performed in earthen retorts, coated with a mixture of clay, iron filings, blood, hair, and alum. These retorts are filled about two-thirds, ranged in a galley furnace, and an earthen receiver is luted to each. The receivers are pierced with a few small holes, to prevent an explosion. The firing lasts eight hours, and when the apparatus is cooled, the red arsenic, mixed generally with some yellow arsenic, is taken out of the receivers; the yellow part is added to the mixture used in the next operation.

The red arsenic thus obtained, is melted over again, under a chimney that has a quick draught, to carry off the vapours. It is melted in a cast iron pot, set in brickwork; when melted it is scummed, and ladled quickly into sheet iron moulds, which are immediately covered and left to cool.

The mixture of the charge must be properly proportioned, so that there may be from $3\frac{1}{2}$ parts to 5 parts of white arsenic, to one of sulphur.

The residue left in the retorts is stored up, and used in making copperas.

Yellow Arsenic, or Orpiment.

Yellow arsenic, or orpiment, is manufactured by mixing arsenical pyrites that have been exposed a long time to the air, with one-tenth their weight of iron pyrites, and distilling the mixture in earthen retorts, as described in the article—Red Arsenic.

Lampadius says yellow arsenic is composed of from $7\frac{1}{2}$ to 9 parts of white arsenic, united with one of sulphur.

Yellow arsenic is also, and more commonly, prepared in the same apparatus as glassy white arsenic, by adding to the $3\frac{1}{2}$ cwt. of powdery white arsenic, that forms the charge of each pot, $\frac{1}{2}$ cwt. of rough brimstone, if the powdery white arsenic is pure; or only 9 pounds of pure sulphur, if the powdery white arsenic already contains sulphur.

Macquer's Neutral Arsenical Salt.

This is manufactured on a large scale, by mixing white arsenic with an equal weight of refined saltpetre, heating it in a crucible until the whole is red hot, dissolving the mass in water, evaporating and crystallizing the solution.

The neutral arsenical salt is used in dyeing; and also in medicine.

This salt is the *bi arsenias kalicus* of Berzelius, or $K \cdot As :: 2$, and its atomic weight is 4,061,370. Dr. T. Thomson calls it *bi arseniate of potasse*, or $As :: 2 K + Aq.$ and its weight, 22,625.

CHROME.

This grayish white, brittle, and scarcely-fusible metal, is not used; but the combinations of its oxide, or as some call it, its acid, with other bodies, are used as colours; and from this circumstance, the Greek name of chrome, *colour*, has been given to the metal itself.

Chrome is not found pure in nature, but all the combinations are made from an ore, in which its oxide is combined with that of iron, and hence called chromate of iron.

Chromates of Potasse.

The ore called chromate of iron being carefully picked, is stamped fine, and being mixed with half, or an equal weight of refined saltpetre, is put into skittle crucibles, so as to fill them about three-fourths of their height. The crucibles are then put into a furnace, gradually heated, and at last kept red hot for half an hour. Being cooled, the crucibles are broken, the yellow spongy mass ground to powder, put along with the shards into a copper, along with 10 times its weight of water, and boiled for about half an hour. When cold, the liquor is filtered, and fresh water boiled upon the residuum, until it no longer acquires a yellow colour.

The several parcels of water being mixed together, are to be evaporated to reduce them to a less compass, and saturated with nitric acid to get rid of the silicate of potasse and aluminate of potasse which they contain. The water is then filtered to separate the two earths, and potasse is added until it again becomes yellow. By a careful evaporation and cooling, the nitrate of potasse crystallizes, and scarcely any of the chromate of potasse which is retained in the supernatant liquor.

This mother water being evaporated, deposits, upon cooling, very beautiful orange red crystals of the acid, or bi chromate of potasse; and the supernatant liquor being again evaporated,

yields a second crop of these crystals. The mother water is now very alkaline, and yields on further evaporation, yellow crystals of neutral or sub chromate of potasse.

Chromate of potasse is used for making chromate of lead ; and also in calico printing.

The bi chromate of potasse, according to Dr. T. Thomson, is Ch_2K , or 19,000 ; and the sub chromate Ch_2K , or 12,500.

[The following process for the manufacture of the chromate and bi chromate of potash is that of an English manufacturer of considerable celebrity, and differs considerably from the foregoing.—Take 100 lbs. of the best American chromate of iron in fine powder, and mix well with 60 lbs. of nitre in powder also ; divide this mixture into parcels of about two pounds each, and wrap them in paper in the form of cones of the same height as the diameter of the base, in the manner in which grocers frequently do up a pound of brown sugar; cover the grate of a furnace, whose height shall be twice that of its length on the side and of a size to correspond with the extent of the manufacture, with a stratum of fragments of charcoal; then put in as many cones with the bases downwards as will cover the stratum of coal; fill the interstices with charcoal, and cover the cones about two inches deep;—lay in another stratum of cones, and so on, until the furnace is filled to within two inches of the top. Throw some burning coals upon the top, and place on the iron cover, which should have a flue of sufficient height to cause a moderate draft. The fire will burn slowly downwards till all the charcoal is consumed. Allow the furnace to cool; then take out the cones, which will preserve their shape, and dissolve out the chromate of potash with a sufficient quantity of water;—saturate the excess of alkali in the solution with nitric acid, and, if the bi chromate be required, add an excess of acid;—evaporate and crystallize the clear solution.

Sulpho Chromate of Potasse,

Is apparently made by mixing the solution of sulphate of potasse, and that of chromate of potasse ; a triple salt is formed, by crystallizing the liquid.

Dr. T. Thomson, who obtained this salt, by mixing the solutions in the proportions of 3 atoms, or $37\frac{1}{2}$ parts of chromate of potasse, and 1 atom, or 11 parts of sulphate of potasse, says the crystals he obtained were composed of 6 atoms, or 66 parts of sulphate of potasse, and 1 atom, or $12\frac{1}{2}$ parts of chromate. 100 parts of the crystals sold in France to the calico printers, are said to contain only about 40 of sulphate of potasse.

Potasse Chromate of Alumine.

This is also manufactured in Germany.

Chrome Yellow.

This beautiful colour is obtained by dissolving sugar of lead in a very large quantity of water, and pouring into it the rough solution of chromate of potasse, from which the nitrate of potasse has been just separated by crystallization, as long as any sediment falls. The liquor is then filtered, and the yellow left on the filters, dried for sale.

Chrome yellow is used as a paint : and it is frequently sold for *peoree*, or *Indian yellow*, which is a gall stone.

This is the *chromas plumbicus* of Berzelius, or Ch_2Pb , and its atomic weight, 4,092,640. Dr. T. Thomson makes this chromate of lead Ch_2Pb , or 20,500.

There is a cheaper chrome yellow manufactured, of a bright jonquil tint, which probably is lowered with alumine.

Chrome Scarlet.

There are several processes for preparing this beautiful colour.

Dulong's is to boil 67 parts of white lead, and 82 parts of chrome yellow, in a sufficient quantity of water. The carbonic acid of the white lead flies off, and the oxide of lead unites with the chrome yellow.

Grouvelle's method is, to boil 41 parts of chrome yellow, and 11 parts of subcarbonate of potasse, in a sufficient quantity of water; the carbonic acid flies off, as before, and the potasse uniting with one half of the chromic acid, leaves the other half with a double portion of oxide of lead.

Chrome scarlet is a good oil colour, possessing a good body, and mixing well with white lead; as a water colour, it has stood for several months in exposed situations, and is equal in colour to red lead.

This sub chromate of lead is, according to Dr. T. Thomson's atomic weights, $\text{Ch} \cdot \text{Pb} \cdot 2$, equal to 34,500.

Besides the metals hitherto mentioned, there are several others which have not yet been used in the arts; and are only made to be exhibited by theoretical lecturers to their auditors: as palladium, nickel, cadmium, manganese or manganium, tellurium, molybdenum, tungsten or wolframium, columbium or tantalum, selenium, osmium, rhodium, iridium, uranium, titanium, cerum; as also the doubtful metals—calcium, barium, strontium, magnesium, yttrium, glucinum, aluminum; and the still more doubtful—selenium, potassium, sodium, lithium, silicon, and iodium.

COMBUSTIBLES.

THIS last class of the subjects of chemistry, is far more numerous than any of the others; but a great part of it is merely natural products, and of course the object of natural history, not of chemistry; another great part is composed of articles made indeed by chemical means, but only in small quantities for medical purposes, to illustrate points of theory, or in the analysis of natural bodies. The operative chemist confines his attention to those substances which are made in large quantities for sale or use.

INFLAMMABLE GASES.

The manufacturing of any gas of this kind was formerly confined to that of hydrogen gas, for filling the balloons used in aerial navigation; but of late, the manufacture of inflammable gas for lighting our houses and streets, has been carried to a very great extent, and become of considerable importance.

Hydrogen Gas.

This gas, the *light inflammable gas* of Dr. Priestley, has been chiefly collected during the solution of iron turnings in weak sulphuric acid, made by adding to oil of vitriol about six times its weight of water. An ounce of iron, according to Mr. Cavendish, produces gas equal in measure to 412 ounces of water; but as the solution is of no value, it is preferable to employ zinc, although an ounce does not produce more gas than is equal in measure to 356 ounces of water, or 5 cubic feet 7 of gas from each, avoird. pound; because the solution being boiled down and crystallized, will yield sulphate of zinc, which is more valuable; 50 pounds of oil of vitriol will dissolve 36 of iron, or 34 of zinc.

A cubic foot of pure hydrogen gas weighs about 40 grains, and of atmospheric air, about 527; but as the hydrogen gas is not absolutely pure, the buoyancy of each cubic foot of gas in the atmosphere cannot be estimated at more than an avoirdupois ounce, from whence the weight of the varnished cloth, cords, valves, and car, must be deducted.

Coal Gas.

This is become the most valuable product of the distillation of coals; and its use is now so extended, that numerous establishments for its production are formed throughout Europe, and even America. The apparatus varies in almost every gas work, but is in general constructed on the following principles:—

The distilling vessels are usually modifications of those directed by Boerhaave to be used in his reverberatory furnace. The cylindrical retorts which are most commonly used, are 6 feet long, and 12 inches in diameter, with the mouth closed by an iron plate, fastened by wedges holding 2 bushels, or 168 pounds of coals, and these, when set two to one fire, and worked so as to distil off all the gas in eight hours, require about 20 bushels of coals to distil 100 bushels. These retorts, cast from iron of the second running, weigh about 10 cwt. and last from 8 to 10 months.

In some works, the section of the retort is not circular, but elliptical, semi-circular, lunulate, or square; and they are set 3, 4, or even 5, to one fire. The setting is also various, for some furnaces have flues round the retorts—in others, an oven or chamber to contain all the retorts, is built over the fire room, or fire rooms, for some of these ovens have three fires to heat them, and contain even as far as 12 retorts. The fire room is sometimes placed towards the front of the retorts, but more generally at their back. In some works, the coals are introduced into the retorts in trays of sheet iron, holding only a small quantity, and frequently changed. In others, very complicated machinery is used to expose a part of a circular box, divided into partitions, to the heat; and when this coal is decomposed, the box is turned round, and another partition exposed to the heat. Attempts have also been made to form the furnace into a coke oven; or to render applicable occasionally to making of coke from the fuel used in the distilling.

The vapours of the heated coal pass off from the retorts by means of a dip or H pipe, which is inserted on their upper side near the mouth, rises about 3 feet 9 inches, and then bends and descends about 2 feet 6 inches, passing through a hole in the upper side of the hydraulic main, and reaching about two-thirds of its diameter. These dip pipes are generally 3 inches in diameter.

The hydraulic main, or condenser, is a large cylindrical pipe from 10 to 14 inches diameter, supported in a horizontal position by iron pillars, parallel to the front of the top of the brick work of the stack of furnaces, about two feet from it, and extending along the whole range. It is generally constructed in lengths of nine feet each, with flanges to screw them together; between each length a semicircular plate is placed, whose upper edge rises $2\frac{1}{2}$ inches above the line of the bottom of the dip pipes, in order to retain a sufficiency of the liquid products, that the gas may always have to pass that depth of liquid before it can enter the main, and that when the mouth of any of the retorts are opened to discharge and recharge them, there may be a sufficiency of liquid to pass up the dip pipe, and operate by its pressure as a water joint to prevent the gas from the other retorts connected with the main, rushing out from the mouth of the opened retort. For which purpose this main is, at the commencement of the work, filled with water; and afterwards, the condensed products keep the partitions filled, running off at one end of the main along with the gas, by a pipe for that purpose; the other end of the main being closed by a plate screwed on air tight.

The pipe, which carries off the tar and ammoniacal liquor along with the gas, from the hydraulic main, communicates with the condensing apparatus; as it is absolutely necessary that all the condensible products should be separated before the gas enters the purifiers. The condensing apparatus is in some a plain straight pipe of great length; in others, a range of pipes laid parallel to each other: both of these contrivances have a considerable declivity. In other works, a worm placed in the gasholder cistern, between it and the gasholder; and still more complicated contrivances have been invented.

As every chaldron, or 27 cwt. of coal yields from $1\frac{1}{2}$ cwt. to $1\frac{1}{2}$ of tar, and from 16 to 20 gallons of ammoniacal liquor, a tar cistern must be provided to collect it, and a communication is formed between the lowest part of the condensing apparatus and the tar cistern, by a pipe of about 3 inches diameter, which passes to near the bottom of the tar cistern, and is enclosed in another pipe, 2 or 3 inches wider, and reaching nearly to the top of the tar cistern; by which means, the gas

is prevented from entering into the tar cistern, and the tar and liquor flows over the brim of the outer pipe. The tar cistern is generally made of cast-iron plates, or of masonry, sunk in the ground; is provided with floats, to show the height of each liquid, and covered to prevent the ammoniacal liquor losing its strength. The liquids are extracted by means of pumps, or sometimes, if the tar cistern is above the surface of the ground, by cocks placed at different heights.

The tar and ammoniacal liquor being thus collected, the uncondensed gas is passed into the purifiers, to separate the incombustible carbonic acid gas, and the fetid sulphuretted hydrogen gas, from the olefiant gas, hydrogen gas and carbonic oxide, which seem to compose the remainder of the raw coal gas. Two methods are employed for this purpose: the exposing of the gas to the action of lime, or the passing of it through red hot pipes, filled with clippings of iron. The lime to which the gas is exposed, is sometimes dissolved in water, or mixed up with it to the thickness of cream, or it is merely wetted with water.

The lime apparatus, when that alkaline earth is dissolved in water, or in the form of cream of lime, is very similar to that of Berthollet for preparing oxymuriatic acid, described in p. 281, and exhibited in fig. 105; but formed on a larger scale, and of cast iron. There exists, however, a considerable difficulty to get rid of the lime refuse, as it is very offensive, and if thrown into pits dug for that purpose soaks through the ground and infects the adjacent ponds, and wells.

The dry lime purifiers, as they are called, are always in pairs, that one may be discharged and recharged, while the other is in action. To purify the gas required for 500 lights, they are each of them about 5 feet square, and 2 or 3 feet deep, formed of cast iron, with 3 or 4 ribs cast internally to support as many shelves of plate iron, at equal distances, perforated with holes about $\frac{1}{4}$ of an inch in diameter, and their centres $\frac{1}{2}$ of an inch distant. The gas enters by a pipe in the centre of the bottom; the top has a trough round it, about 6 inches wide and 10 deep, filled with water to receive the cover and form a water joint to prevent the gas escaping that way; the exit pipe is on the side near the top. To charge this purifier the cover is removed, the upper shelves taken out, the lower shelf is then covered evenly 3 or 4 inches deep, with new slaked lime, so far wetted as not to adhere to the hands, and a gallon of water poured on it. The other shelves are then put in, one by one, and covered with lime; and finally, the cover being put on, and the gas admitted, it is forced to make its way through the several layers of wet lime. The

lime when discharged, is thrown into a cistern, through which the air that feeds the fire is made to pass, and thus the disagreeable odour of the saturated lime is destroyed, and the lime itself is rendered of considerable value as a manure, and has been sold at an advance of one-twentieth on its original price.

A bushel of quicklime, or 2150 cubic inches, is required for the purification of 12,000 cubic feet of gas; by slaking, most kinds of lime double their original bulk. The hundred (pecks) by which lime is usually sold, is about 27 cubic feet.

The purification, by clippings of iron, requires two retorts, which are generally heated by one fire, as they are worked only at a red heat just visible by day light. Each of these retorts are divided lengthwise down the middle, by the partition cast along with them, and reaching nearly to the hinder end; the mouths of each division of these retorts is closed by a separate plate, secured as usual. The pipe conveying the gas from the condensers into these purifiers, is like that of the dry lime purifiers, branched so that the gas may be introduced into either of them at pleasure, and shut off from the other. The retort being charged with iron clippings in each division, the mouth secured, and the retort brought to the proper heat, the gas is let on, and passes of course into one of the divisions of the retort; then passing behind the partition, it passes through the other division, and is conveyed from thence by a pipe to the gasholder. A small cock, to which bladders may be applied, is placed on the exit pipe between the purifying retort and gasholder, for the purpose of examining the purity of the gas, by infusion of archel, sugar of lead water, or diluted nitric solution of silver. When the purity of the gas decreases, the other retort is charged, the gas let on to it, and the first retort discharged and recharged.

The gasholder is on the same construction as Accum's, described in p. 213, and exhibited in fig. 102, but on a large scale, generally holding 15,000 or 20,000 cubic feet; or 30 to 40 feet diameter, and 18 or 23 feet high. They are now made of sheet iron, weighing about two avoird. pounds, 11 ounces, by the square foot; and are usually worked at two inches pressure of water, the pressure being ascertained by a small pressure gauge attached to the top of the gasholder. The equality of pressure is secured by making the weight of each foot of the chain suspending the gasholder, equal to the weight of water displaced by the gasholder being sunk to that depth in the tank.

The gas is then conveyed by pipes to the places where it is wanted.

Retorts, whose vertical section is elliptical, are generally

preferred; five of them are capable, upon occasion, of distilling 45 bushels, or 33 cwt. of coals, every day, and produce 17,000 cubic feet of gas; but their average daily mode of working may be estimated at one chaldron, or 27 cwt. of coal, so as to produce from 12,000 to 14,000 cubic feet of gas, and a chaldron $\frac{1}{2}$ of saleable coke. The labourers find it easier to work these retorts, even when the four hours' process is followed, than the same number of cylindrical retorts at the eight hours' process; as their shape allows the coke to be raked out more rapidly, especially as it is not so compact.

An improvement has been attempted, by introducing water into the front of the retort: a bent iron pipe to form a hydrostatic funnel, the steam of which will tend to separate the coaly matter from the gas.

Oil Gas.

The apparatus for procuring this gas, is similar to that for coal gas, but constructed on a smaller scale; the following are the necessary variations:—

The retort, which is charged with pieces of hard brick, renewed from time to time as often as they lose the power of decomposing the oil, has besides the dip pipe near its mouth, another pipe, bent so as to form a hydrostatic funnel, and passing from an oil cistern placed above the furnace, to near the mouth of the retort, and from thence within it, on the upper part, to near the middle. This pipe is also furnished with a cock, by turning which, the charges of oil are made to flow into the retort.

The gas, in passing from the hydraulic main to the gasholder, passes through several vessels filled with oil, to condense any oil that may have been volatilized without decomposition; and as this gas does not contain any sulphuretted hydrogen, this is the only purification that it requires.

Oil gas is procured in England from whale oil.

A ton of good whale oil produces 25,000 cubic feet of gas. A gallon of cod oil produces but 85 cubic feet $\frac{1}{2}$ of gas.

As its illuminating power is rather greater than that of coal gas, it is used for portable gas lamps. These lamps are much cleaner in their use than oil lamps; but the experiments of Messrs. Herapath and Rootsey tend to show, that there is a loss of 28 parts in 100 of illuminating power, by converting oil into gas, instead of burning it in an Argand lamp.

Rape oil has been tried in France for producing oil gas; but it contained so much sulphuretted hydrogen gas, that its use has been abandoned.

Coal-Tar Gas.

The difficulty of selling the tar obtained in the manufacture of coal gas, led to attempt the use of it for making gas; but it was found to clog up the pipes with such abundance of carbonaceous matter, as occasioned its use to be speedily abandoned.

Messrs. Vere and Crane obviate this inconvenience by mixing steam with the volatilized products. The apparatus is the same as for coal gas, with the addition of two iron pipes, bent so as to form hydrostatic funnels, one of which is inserted into each end of the retort; and a sheet iron tray, which is introduced into the retort: the remainder of which is filled with broken bricks, the mouth is then closed up, as usual, and the retort heated.

The cock of a water cistern, placed in the front of the furnace, being then turned, the small stream that flows into the retort is instantly converted into steam, and passes through the dip pipes. The cock of the tar cistern, placed behind the furnace, is then opened, and some tar admitted, which falling on the red hot tray, is converted mostly into gas, and obliged to mix with the steam. By this very simple means, the impurities which rise with the gas are separated, and settle upon the broken bricks, and the gas passes into the dip pipes free from superabundant coaly matter.

The dish or tray must be changed as often as it gets filled with the residuum of the tar, and also the bricks as they get clogged.

DENSE SIMPLE COMBUSTIBLES.

Of the substances arrangeable under this head, only two are the object of operative chemistry: namely, sulphur and phosphorus. For selenium is not hitherto found to be of any use, while bore and silicon, if they belong to this genus, are in the same case, as well as potassium and sodium.

Sulphur, or Brimstone.

A very large part of the sulphur used in the arts, is obtained from the cracks and crevices in volcanoes, where it collects by the condensation of the sulphurous vapours. This native sulphur is generally purer than that collected at the mines during the roasting of the ores.

As great quantities of sulphur are consumed in its various uses; it is also obtained by distillation from the ores that contain it in a large proportion, as iron pyrites.

Near Liege, a number of long earthen pipes, rather wider at one end than the other, and open at both ends, are placed across the chamber of a long narrow furnace, so that the narrowest end is rather lower than the other. This narrowest end is stopped with a star of baked clay, to prevent the pyrites from falling out, but allowing the sulphur and its vapour to pass. The vessels are then charged with 30 pounds each of pyrites, the wide end stopped with clay, and the fire being lighted, the sulphur runs out at the lower and narrow end into tubs or pots, filled with water.

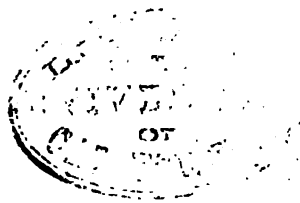


Fig. 212

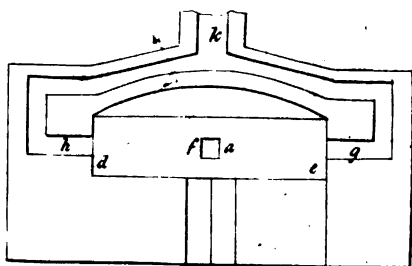
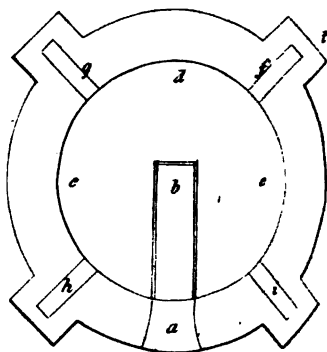


Fig. 211



0 10 feet

Fig. 213

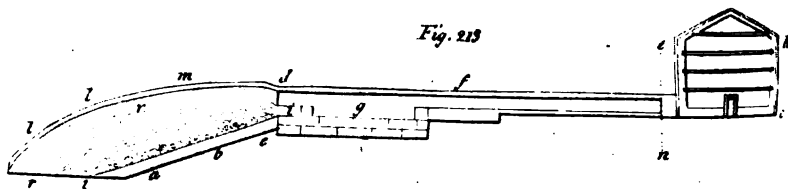


Fig. 214

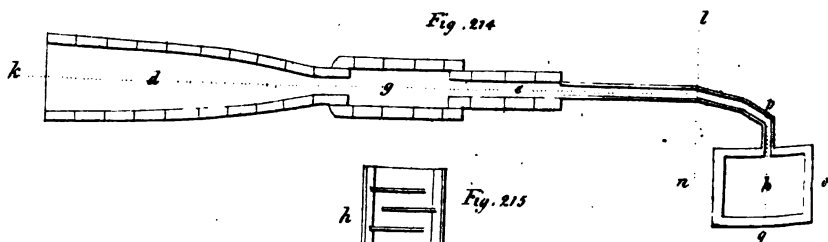
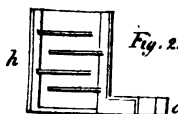


Fig. 215



0 10 feet

It takes about 35 cwt. of iron pyrites to obtain one cwt. of rough sulphur.

In some places, iron pyrites are distilled in large cast-iron retorts.

Fig. 213, represents the vertical section of the furnace, which was invented by Dr. Gahn, and has been used for some years at Fahlun, in Sweden, to obtain sulphur from iron pyrites; the section being in the line, *k, d,* and *n, o,* of fig. 214, which is the plan of the furnace. In both these figures, the long channel, *f, e,* is broken off at *e*; if it were represented entire, the channel would be about 42 feet long beyond the dotted line, *e, n,* before its turn round.

Fig. 215, is the vertical section, in the direction *q, p,* fig. 214.

Upon the slope, *a, b,* of a bank, *a, b, c,* pieces, *r,* of iron pyrites are placed upon billets of wood, *i, i.* A channel, *d, f, e,* leads from the space, *r.* This channel is covered with slabs of stone as far as *f,* and from hence unto the chamber it is formed of planks. A receiver, *g,* is placed at the beginning of this channel. The chamber, *h,* is divided into five parts by horizontal divisions, which allow a passage for the vapours from one division to the other.

The pyritous ore, *r,* having been piled on the billet wood, *i, i;* as soon as this is thoroughly on fire, the ore is covered with smaller ore, and afterwards with earth, *l, l,* heaped upon it; except that about the part, *m,* for the breadth of a foot, the ore is covered with flags of stone. By moving these stones, the burning of the pile is regulated. Part of the sulphur distils into the receiver, *g,* from whence it is taken out occasionally; another part subliming, passes along the channel, *f, e,* and into the chamber *h,* from whence it is taken out and washed with water, to separate the sulphuric acid with which it is sometimes impregnated. After this washing, it is refined by distillation.

The ore from whence the sulphur has been thus separated, is used as a common red paint, much used for wood work.

The rough sulphur, or brimstone, is refined by distillation in large cast-iron retorts, or in iron bodies, covered with earthen ware heads, containing about 6 cwt. of brimstone. These distilling vessels communicate with earthenware receivers, with three openings; one on the side near the top to receive the neck of the distilling vessel, one at the top to let out the vapours which arise in great quantity, and the third near the bottom, by which the refined sulphur runs out in vessels filled with water. Rough sulphur, or brimstone, loses about one-eighth of its weight in this operation.

The refined sulphur thus obtained is melted, and poured into moulds of beech wood, well moistened with water.

Sulphur is for many purposes reduced to flowers, which is performed in a sulphur-house, consisting of two rooms, one above the other. The lower room contains a stack of furnaces, with several iron pots, the fires being attended on the outside of the room. The sulphur is kept melted in these pots, and being volatilized, ascends into the upper room through a large opening in the ceiling.

Brimstone, or rough sulphur, is also refined in a very thick cast-iron pot, capable of holding 10 or 12 cwt. of brimstone. This pot is covered with a hemispherical dome of brick work,

having two openings; one for the purpose of charging and discharging the pot, and which is closely stopped, and the joints luted at other times. The second opening communicates with a brick chamber on one side of the furnace: the size of this chamber is various. If it is proposed to manufacture roll sulphur, the chamber need not measure more than 600 cubic feet, and it must have several gutters level with the floor, with stoppers, to let the melted sulphur run out into the moulds. But for manufacturing flowers of sulphur, the chamber must measure about 3000 cubic feet. In either case the chamber must have on the side a man hole capable of being kept closely stopped, and at top a trap, to let out the rarefied air. With chambers of this size 2 cwt. of brimstone may be distilled by the hour. A pot an inch thick will last only four or five months, if in constant use.

Sulphur is used in the manufacture of oil of vitriol, and is burned in closets for bleaching. Sulphurous acid is obtained from it, and fire matches are tipped with it. The making of gunpowder consumes an immense quantity.

Phosphorus.

To obtain phosphorus 24 pounds of bone ash are put into a tub, and as much water added as to reduce it to the form of a thick soup, 20 pounds of oil of vitriol are then added, which renders the liquid much thicker, and more water must be added to dilute it, and the whole left for a day and night.

Boiling water is then added, the whole stirred up and left for some time to settle; the liquor at the top is taken off and filtered through canvas. Fresh boiling water is added, and the filtering repeated until the water is no longer acid.

The solution of acid phosphate of lime which is thus obtained, contains some sulphate of lime; to get rid of which the water used for washing the bone ash must be evaporated in a leaden or copper boiler to the consistence of a syrup: the sulphate of lime separates as a sediment. To this concentrated liquor three or four times as much water is to be added, heated, the whole filtered, and the sulphate on the filter washed until the water has scarcely any taste.

The liquor that passes the filter is again evaporated to a syrup, and mixed with $\frac{1}{4}$ its weight of charcoal powder, and calcined almost at a red heat in a cast-iron pan, to dry it thoroughly, and prevent its puffing up when distilled. The distilling vessel ought to be a stone ware retort, which may be filled three-fourths or four-fifths of its capacity; to its neck is luted a copper pipe, which passing through a cork, goes down to the bottom of a large stone jar half filled with water; this jar is also furnished with a gas pipe passing through the cork, $\frac{1}{2}$ inch in diameter, and two or three feet long.

The furnace in which the retort is placed must give a very strong heat; the fire is brought on slowly, the phosphorus begins to come over in about four hours, as is known by the phosphurated hydrogen gas that passes through the gas pipe taking fire, and the fire must be governed by the appearance of this flame. The whole operation usually takes up 24 or 30 hours, and each avoird. pound of the phosphate produces an ounce $\frac{1}{4}$ of phosphorus, some of which sticks to the copper pipe, and even to the neck of the retort.

The phosphorus being collected, is tied up close in a piece of chamois leather, put into water nearly boiling, and strongly squeezed with pincers to force the phosphorus through the leather. When the water has cooled to about 115 deg. Fahr., glass pipes are dipped into the phosphorus, which is sucked up by

the mouth until it fills one-half or three-fourths of the pipe; the lower end of which is then closed with the finger, and the pipe removed into a pail of cold water that the phosphorus may set. It is afterwards pushed out from these pipes, and preserved under water in a dark place.

Sometimes the phosphorus is redistilled in a glass retort: but not more than three ounces should be distilled at once for fear of accidents.

Phosphorus is used only as a means of procuring a light.

ARDENT SPIRITS.

These spirits are missible with water in any proportion, and when pure totally inflammable.

The principal use of these spirits is as an exhilarating drink, too frequently abused to produce drunkenness. They are also used to preserve animal and vegetable substances, by immersion in them; and the strongest and purest in the preparation of varnishes, and as a clean fuel to burn in lamps.

Common Brandy, or Spirit of Wine.

This is the ardent spirit extracted from the high-coloured white, or pale red wine, and forms one of the staple manufactures of the South of Europe.

The wines of the countries nearest the Mediterranean Sea, furnish the greatest proportion of brandy; and this proportion diminishes as the grapes grow in more northern climates. The wines of the South of France yield one-fourth of brandy, some even one-third; while in the North of France the wine yields only one-eighth or even one-tenth.

White wines are preferred by distillers, not only because they yield more brandy than the red, and of a sweeter and better flavour; but also because they fine sooner, and may be distilled before the red are ready for the still. As they are not so much esteemed for drinking as the red, they are also cheaper.

The body of the still being filled to three-fourths its capacity, the head fitted both to the body and worm, and the joints closed by wrapping a strip of pasteboard round them, and fastening it on by an iron hoop, drawn close by screws and nuts. The fire is lighted and brought on quickly, until the first spirit begins to distil, when the fire is slackened, and kept at an even pitch, so that the spirit runs from the worm in a fine continued thread.

When nearly the expected quantity of spirit is distilled, the liquor that runs from the worm is assayed from time to time, either by the hydrometer, or by shaking in a phial and observing the bead; or, which is most usual in large distilleries, by receiving some in a wine glass, throwing it on the still head, and applying a candle to it, to find whether when thus vapourized it takes fire. Some distillers have a cock in the body, which serves to show when it is full, and which they turn occasionally and apply a candle to the vapour that issues, for the same pur-

pose. When the vapour thus produced ceases to take fire, the brandy, or eau de vie, is reputed to have all come over, and a fresh can being applied to the end of the worm, the *eau de vie seconde or repasse*, is generally collected separately, to the quantity of one-fourth of the first eau de vie; but if the brandy is designed for home use, the worm, to use the French phrase, is not cut; but the seconds are allowed to mix with the first portion. The liquor that remains in the still is called *vinasse*; and this being drawn off, a fresh portion of wine is poured into the still, and thus the distillation is continued without interruption, until all the wine is expended. In France, they only distil from the beginning of October to the end of May, and this they call a campaign.

Brandy is sold in France of two degrees of strength: namely, Eau de vie a preuve de Hollande, and a preuve d'huile; the first is very nearly 19 deg. of Baumé, and the second 23 degrees.

When a spirit of superior strength is required, the brandy is re-distilled, and three quarters of it drawn over in the common still, with a gentle heat, so that the thread from the worm may be extremely fine; and the spirit as it comes over is separated into different portions, as the strongest spirit comes over first; this distillation occupies two-thirds longer time than that of the same quantity of brandy. Some persons use a water bath.

These superior kinds of spirit are in France estimated by the quantity of Eau de vie à preuve de Hollande, that they will make by the addition of water, and are usually made of twelve strengths, five-six, four-five, three-four, two-three, three-five, four-seven, five-nine, six-eleven, three-six, three-seven, three-eight, and three-nine, but this last is rarely manufactured. These apparent fractions are not to be read five-sixths, but five-six; that is to say, five measures of this spirit will make six à preuve de Hollande.

The spirit five-six, is allowed to be equal to 22 deg. Baumé, or sp. grav. 0.9237; but the other strengths are variable, in consequence of the uncertainty respecting the strength of the spirit, preuve de Hollande, which varies from 18 deg. to 20 of Baumé.

The repasse, or eau de vie seconde, is also re-distilled; and 3 qrs. of it drawn over.

The vinasse still contains a little wine; it grows sour very soon, and is used in some arts.

Spirit of wine, when first distilled, is as clear as water; and if preserved in earthen or glass vessels, keeps its colour; but in oak casks it becomes high coloured. Spirit is sold weak for the consumption of the neighbourhood; but when intended for distant markets, it is sold very strong, generally three-six, to

save the expense of carriage, and when it arrives at its place of consumption, reduced by adding water or weak spirit.

Although brandy is a staple manufacture of France, their stills until the late improvements were very small, and still continue so in most places. The usual size is only 21 inches deep, 34 inches wide at top, and 30 at bottom; they are all tinned on the inside, and covered with a plain moor's head of tinned copper, or tin plate.

The consumption of fuel and produce has been thus stated:— 925 pounds of wine consumed in their distillation 60 pounds of pit coal, and produced in 5. hours 42 minutes, 87½ pounds of eau de vie preuve de Hollande, and in 2 hours more, 98 pounds of repasses.

In re-distilling brandy, to avoid loss of the strong spirit by evaporation, it is usual to receive it into a close barrel, joined to the end of the worm by a lantern, which is two funnels soldered together at their wide ends; and the upper funnel has two small panes of glass let into it, that the thread of spirit may be seen.

The improvements made in distilling spirit are of two kinds; those relating to the common apparatus, in which spirits of superior strength is obtained by repeated distillations, and the still greater improvement of avoiding re-distillation, obtaining spirit of any required strength at once, and completely exhausting the wine, so that the vinasse is totally useless.

The improvement in the still body has been to make it large, very wide, and shallow: some have made its bottom convex internally, but the propriety of this form is disputed. The neck has been made very wide as well as the beak of the head, so as to allow a free passage to the vapour. It has also been found advantageous instead of a thick pewter pipe of small diameter for the worm, to use a tinned copper pipe of several inches in diameter.

M. Poissonier, in 1779, proposed the following apparatus as the ultimate perfection of which the common still was susceptible; it is evidently taken from Weigel's Essays, which were published that year.

Fig. 216 is a perspective view of this apparatus. *A* is the body of the still, two and a half feet in diameter, and close at top excepting the two openings *b* and *c*. *B* is a round opening, a foot in diameter, in the middle of the top of the boiler, for the purpose of charging and cleansing the still. This opening has a double rim, and is closed by a cover, *V*, which has also a double rim. The first drops of vapour that are condensed form a water joint. *C* is the furnace in which the still body is set, and *d* is the discharge cock. *E* is a square opening, six inches each way, towards the back of the still body: to this opening is soldered a square turned copper pipe of the same size, and as many feet long as the place will allow. This pipe serves as the head of the still, and also

as the condensing apparatus. *F* is a square copper pipe, in which the pipe is enclosed the greater part of its length: this pipe is an inch and half larger each way than the inner pipe, which is kept in the middle by proper stays. The two pipes slope at the rate of half an inch in a foot. *G* is the partition wall between the room, or shed containing the furnace, and that containing the condensing apparatus; to prevent the warmth of the fire from affecting the condensation, or the odour of the vinasse discharged from the still, and which is frequently very disagreeable, from affecting the brandy that is obtained. *H* are tressels to support the condensing apparatus; and *i* are iron standards affixed to the tressels to keep it in its place. *K*, is a pipe with a cock, soldered to the end of the pipe *e*, by which the spirit runs into the funnel, *l*, and is thus conveyed into the receiving tub, *m*. *N* is a leather hose, or pipe that transmits the water, used in cooling the vapours, from the cistern, *o*, to the lower end of the condensing apparatus, between the two square pipes of which it is composed. *P* is a small press composed of two pieces of wood, connected together by a screw, by turning of which, the distance between the pieces may be altered at pleasure. This press is used to regulate the flow of water through the hose, instead of a cock. *Q* is the discharge pipe of the water employed in cooling; this pipe is soldered to the top of the outer square pipe, and conveys the heated water either to the sink or any other place.

This apparatus is stated to distil from 28 to 30 quarts of brandy by the hour, but its produce would, of course, be much greater in proportion, if made on a larger scale.

The still and condensing apparatus of M. Poissonier, or more justly speaking, of Prof. Weigel's father, would probably have been gradually adopted by all the French distillers, if M. Adam, a distiller of Nimes, attending a course of chemistry at Montpellier in 1799, had not conceived the idea of applying the condensing apparatus of Glauber and Wolfe in the distillation of wine. His success was so great that a complete revolution has taken place in the apparatus, and the common stills with their various improvements, are only used by persons who distil the wines of their own growth, or by those distillers, the smallness of whose capital does not allow them to adopt the new apparatus.

The apparatus of M. Adam led the way. That of M. Solimani, a physician of Nimes, who formerly lectured on chemistry and experimental philosophy, and disputes the priority of invention with M. Adam, although his brevet is dated a few days later in July, 1801: and that of M. Berard, a distiller of Grand Gallargues, also of the department du Gard, breveted 16th of August, 1805, which is perfectly original, are here described, and all the other apparatus hitherto proposed may be considered as mere variations or combinations of these three.

The apparatus of M. Adam is the most in use; which is not through its superior merit, for it is considerably inferior to the other two, but from his litigious disposition; for having obtained a brevet "for obtaining from wine all the alcohol it contains, he considered all improvements in distillation within its reach, and prosecuted every person who used any apparatus but his own for this purpose; so that the distillers were afraid to adopt

Fig. 216

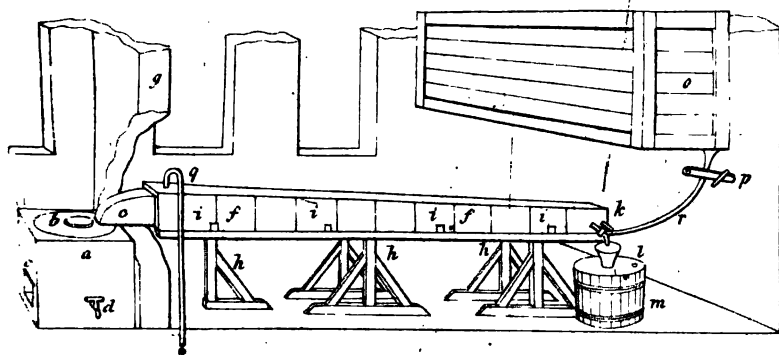


Fig. 217

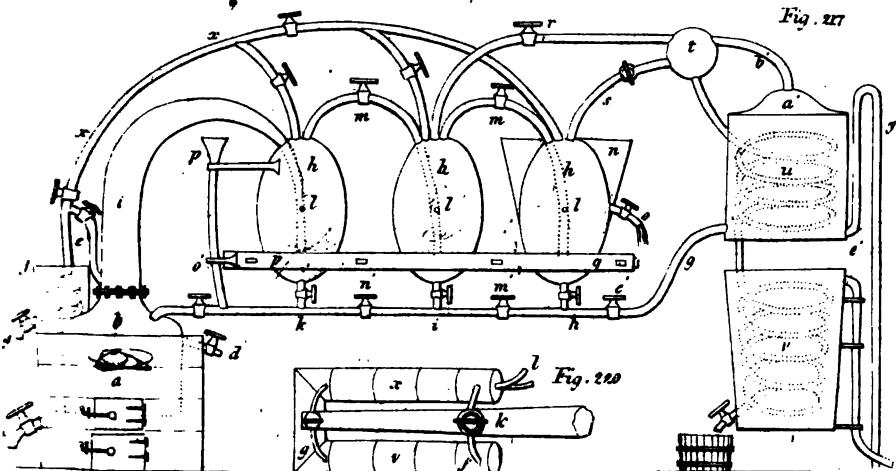


Fig. 218

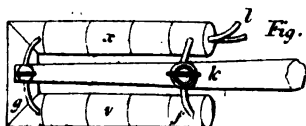
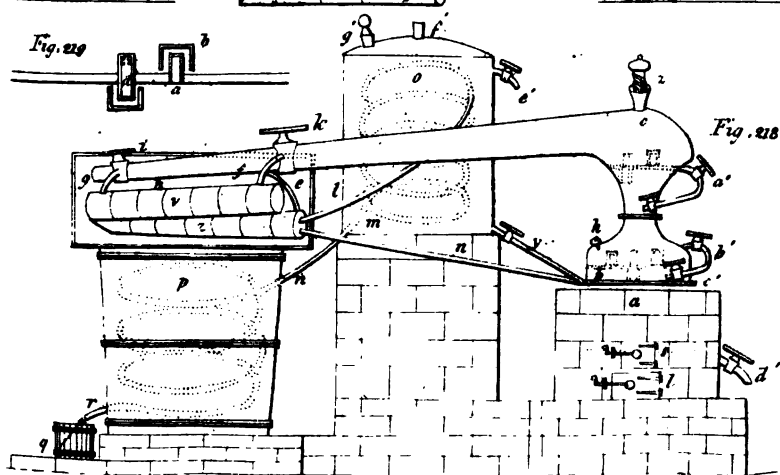
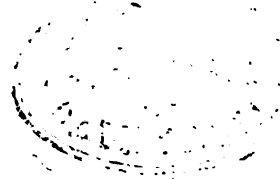


Fig. 219



Fig. 220





any other, as it would have involved them in a law suit; and those who have thus got this apparatus continue to use it. This litigious disposition of M. Adam was its own punishment; for after having acquired a handsome fortune by his own distillery, he was ruined by the expenses of the numerous law suits in which he engaged, and which after years of litigation most commonly terminated against him, and he was condemned to pay the whole costs of the suits.

All these improvements are founded on these principles. Wine consists of a mixture of water and alcohol, which ingredients differ in the temperature at which their vapours condense into a liquid. The condensing part of the distilling apparatus being then divided into two portions, and that next the still body kept at the temperature at which the vapour of water condenses, it becomes a liquid, and is made to flow back into the body, while the vapour of the alcohol not being condensable by this temperature, pass on to the second portion of the condensing apparatus, which is kept at a lower temperature, and here it is also condensed and made to flow out into the receiver.

The original apparatus of M. Adam was a clumsy imitation of Glauber, but he afterwards simplified it.

Fig. 217, exhibits a view of his simplified apparatus, without the frame work necessary to support the various parts. It is represented with three eggs, although a few distillers use four, and his original apparatus had six or eight.

A, is the furnace in which is set the body of the still, *b*. *C* is the discharge cock of the still. *D*, is another cock, placed at two-thirds the height of the body, to show when the still is filled so far. *E*, is a small pipe from the neck of the still to the long pipe, *x*, which connects the last egg with a small worm contained in a tub, *f*, for the purpose of proving the vapours contained in each of the distilling vessels; this worm has a cock, *g*, to close it. *H*, are three distilling vessels, in the form of eggs, fixed upon a frame, *p*, *q*. The body of the still communicates with the first egg, by the pipe, *i*, serving as a head to the still; this pipe goes to the bottom of the egg, and has at the end a rose, like that of a gardener's watering pot, the holes being about one-eighth of an inch in diameter. *L* are cocks, to show when the eggs are half full. The first egg communicates with the second, and the second with the third, by the pipes, *m*, each of which go from the top of the egg to the bottom of the next, and have roses at their ends. The third egg is furnished with a bucket, *n*, soldered to its upper end, and filled with water to condense the vapours; this bucket has a cock, *o*, to discharge the water when too hot. When the apparatus is furnished with four eggs, the two last have refrigeratories. *R*, is a pipe that connects the second egg with the globular vessel, *t*, and of course with the great worm, when only two eggs are used, in order to distil brandy à preuve de Hollande. *S*, is a pipe that connects the third egg with the globular vessel, *t*, and great worm. *U*, is a close vessel, which contains the first part of the great worm; the vessel is filled with wine, by means of the pipe, *y*, which is connected with a forcing pump fixed in the stone cistern containing the wine. *V*, is a large tub containing the second and larger part of the worm; this tub is filled with water by means of a pipe entering into it towards the bottom, and not shown in the figure; as the water grows warm, it rises in the tub, and is discharged by the pipe, *z*. *X*, is the head of the vessel, *u*, furnished with a pipe, *v*; to convey the vapour of the heated wine into the globular vessel, *t*; there is a continuation of this pipe, not expressed in the figure, by means of which the vapour

may be conveyed either into the body of the still, or into one of the eggs, at pleasure. *G'* is a pipe connecting the vessel, *u*, of heated wine, with the body of the still, and each of the eggs. *H'*, *i'*, *k'*, are cocks to regulate the connexion between the eggs and the pipe, *g'*. *L'*, *m'*, *n'*, *o'*, are cocks to regulate the connexion of each egg, either with the vessel, *u*, to charge them, or with the body of the still, to discharge them. *P'*, is a funnel, by which brandy or repasse is charged either into the body of the still, or the eggs; this cornucopiz, as it is called, is fixed to the first egg, and the egg frame, *p*, *q*, by iron stays. The whole apparatus is made of tinned copper, and the pipes soldered together.

Although this apparatus has always a bucket to the last egg, or two, many distillers think them useless, and do not use them even when they intend to obtain only spirit of wine three-six.

The operation is begun by opening the cocks, *m*, *s*, *d*, *k*, *m'*, *n'*, *o'*, and pumping wine into the vessel, *u*, until it begins to run out of the cock, *d*, which is then shut, as also *o'*; and *k'* is opened as also the cock, *l*, of the first egg. The wine then is forced into the first egg, and as soon as it runs out of the cock, *l*, the cocks *n'*, *k'*, and *l'*, are shut; and *i*, is opened, as also the cock of the second egg; thus the wine is forced into the second egg, and as soon as it runs out by the cock, *l*, the cocks, *n'*, *i'*, and *l*, are shut, as also *l'*; and the pumping is continued until the vessel, *u*, is nearly filled. The refrigeratory of the condensing egg, *n*, is then filled with water, as also the tub, *v*.

The apparatus being thus filled, the fire is lighted, and the vapours of the wine pass into the first egg, where some part being condensed, heats the wine in it, and its vapour joined with the other, pass on to the second egg, and from thence to the third egg, or condenser, where part is condensed, and the remainder goes on to the worm, and flows into the receiving tub.

The strength of the vapour arising from the body of the still, or any of the eggs, is tried by opening the communication between them and the small worm, *f*, and cutting off that to the large worm, in *u* and *v*; the spirit being received in a glass, is examined either by the hydrometer, or otherways. When the liquor in the body of the still is exhausted, the fire is withdrawn, the communication with the eggs, or great worm, is shut, and the discharge cock, *e*, opened. If it also appears that the liquor in any of the eggs is exhausted, it is run off at the same time by opening the necessary cocks; but the liquor in those that are not exhausted, is run into the body of the still, and the filling of the body is completed by adding some repasse, by the cornucopiz or wine, from the vessel, *u*. The first two, or distilling eggs, are then filled either with wine from the vessel, *u*, or if it is intended to obtain a strong spirit, with brandy, by the cornucopiz.

As the passage of the vapours through the liquor in the eggs, occasions a great expansive force within the body of the still, it must be made stronger than ordinary.

Dr. Solimani's still is evidently distillation by steam, with a highly improved condensing apparatus.

Fig. 221, represents a geometrical elevation of Dr. Solimani's still, being part of a set of two stills, placed on each side of a chimney, *t*, and cooler, *y*, common to both; in the still not shown in the figure, all the parts are of course reversed in situation, the fire being at the end farthest from the chimney. Fig. 222, is a section of the same.

A, is a pipe to convey wine from its cistern into the stills, by means of the cock, *b*, and the pipe, *c*. *D*, are two still bodies, 4 feet square, and only 18 inches deep, but connected together by a pipe, *e*. The necks are cylindrical, nearly 3 feet wide, and just long enough to pass through the stone vault, *f*. On these necks are placed low heads, with wide beaks, *g*, which are soldered to a pipe, *e*, by which the vapours are forced to descend to the bottom of the close copper barrel, *f*, where part of them being condensed, form a stratum of

Water, through which the succeeding vapour is obliged to pass. *G*, is a wide pipe, which conveys the vapours from the vessel, *f*, into the dephlegmator, or alcogene, contained in the tub, *h*.

This dephlegmator is formed of two broad sheets of tinned copper, soldered together so as to leave only one-sixth of an inch between them, and bent into four inclined planes, as shown in the adjoining section, fig. 224. It is enclosed in a tub of water, which is kept at a uniform temperature by a regulating apparatus hereafter described. *I*, is a pipe that conveys the vapours not condensed in the dephlegmator, into the refrigeratory contained in the water cistern, *y*. The refrigeratory is formed like the dephlegmator, of broad sheets of tinned copper, soldered at a small distance from each other, and forming six inclined planes, as in the adjoining section, fig. 223; the spirit being condensed in this refrigeratory, flows out by the pipe, *k*. *L*, is the pipe that supplies the regulating apparatus of the tub in which the dephlegmator is placed, with cold water. *M*, is a bent pipe, to convey the phlegm collected in *f*, when it reaches the level of the bend of the pipe, into the pump tub, *n*. *O*, is the handle of a forcing pump, by which the phlegm is returned into the still bodies, by means of the pipe, *v*. *P*, is a door, by which a workman can get into the furnace, to repair it. *Q*, is the door into the fire room, which is only a foot square. *R*, is the ash room door. *S*, is the receiving can. *T*, the chimney, which serves for both furnaces. *V*, is the pipe by which the phlegm is conveyed back into the body of the still. *X*, is the pipe that conveys cold water from a cistern into the refrigeratory cistern, *y*, and the vessel in which the dephlegmator is placed. *Y*, is a stone cistern, containing the refrigeratories of the two stills. *Z*, is a pipe to convey the steam into the chimney.

A, is a flat shallow copper boiler, about 10 feet long and $4\frac{1}{2}$ feet wide: it contains only about 8 or 12 inches deep of water, whose steam is employed to heat the still bodies, supported over it by the iron bars, *c*. *B* is part of the flue under the boiler, which is eight inches square at the fire room, and grows smaller by degrees: it is passed from side to side, so as to be nearly 36 feet long before it reaches the chimney. *C*, are the iron bars that support the still bodies: the boiler being firmly fixed in the walls and covered with a stone arch, *f*, in which is a steam pipe, *z*, that conveys the steam of the water in the boiler into the chimney, *t*. *D*, is a glass pipe cemented into a copper pipe connected with the boiler, to show the depth of water in it. *E* is a pipe that connects the two still bodies together. *F*, is the stone vault confining the steam. *G* are the beaks of the stills resting on the stone vault. *H* is a pipe bent upwards, with a cock, and funnel by which to convey water into the boiler, *a* when wanted. *I* is the discharge cock of the still body. *K*, is a glass pipe like *d* to show the depth of wine in the bodies. *L*, the waste pipe of the dephlegmator tub, and *m* that of the refrigeratory cistern. Fig. 225 represents the regulating apparatus, fitted in the tub *h*, drawn on a large scale. *A*, is a section of the tub on one side of the dephlegmator, or alcogene. *B*, is a box fixed on the side at the bottom. *C*, is a valve of at least a sufficient weight to resist the pressure of the water entering the tub by the pipe, *d*. *E*, is the level at which the water is kept by the waste pipe, *f*. *G*, *h*, is a floating ball, bearing on its upper stem, *i*, *k*, a basin, *g*, for weights. *L*, *h*, is the lower stem of the float, with a ring at the bottom. *M*, *n*, a sliding rod passing through the side of the vessel, and supported by the bracket, *o*, *p*: this rod has a ring at the end, *m*, through which the upper stem of the float passes, and by which it is kept upright. *Q*, *r*, is another rod, with a knob at the end, *g*, and a hook at the end, *r*, to which hangs the valve, *c*. *S*, *t*, is an upright stem, with a ring at the upper end, *t*, through which passes the rod, *q*, *r*. *V*, is the water way stopped by the valve *c*. *U*, is the stem by which the valve, *c*, hangs on the hook, *r*. *X*, *y*, is a horizontal stem fixed in the side of the vessel, and with a ring at the end, *x*, through which passes the stem, *u*.

The action of this regulator depends on the specific gravity of the water decreasing as its temperature increases, and hence the floating ball descends. The basin therefore is loaded so that at the temperature at which it is desired to keep the water in which the dephlegmator is plunged, it shall be an exact



counterpoise to the upward pressure of the water on the valve, *e*. When the water gets warmer the float descends, and by its lower stem, *l*, *h*, lowers the end, *q*, *t*, of the lever, *q*, *r*, and thus raising the end, *t*, *r*, causes the valve to rise up and admit the cold water, until the temperature of the whole is so lowered, that the float rising, by an opposite movement shuts the valve. If it should be found that it requires a great change of temperature to cause the float and valve to act, the rod, *m*, *n*, is to be pushed farther into the vessel, and at the same time the lower stem of the float is to be pushed more towards the end, *q*, of the lever, *q*, *r*; the float being thus made to act by a longer lever, it will be enabled to lift up the valve with a less force, and the water will be kept at a more uniform temperature.

The boiler is first filled with water through the pipe, *h*, to the proper height, as shown by the gauge pipe, *d*, and the fire lighted. In the mean time wine is run into the still bodies by turning the cock, *b*, until they are filled at the necks, as shown by the gauge pipe, *h*. The steam of the water heating the still bodies, the vapours of the wine rise into the heads, and are forced to descend the pipe, *e*, into the vessel, *f*, where part of the watery vapours are condensed, and lodged on the bottom of that vessel until the phlegm rising above the level of the arch of the syphon, *m*, it runs into the vessel, *n*, from whence it is occasionally pumped up the pipe, *v*, into the still body again to be completely exhausted. The uncondensed vapours pass through the pipe, *g*, into the lower part of the dephlegmator, where the remainder of the watery vapour is condensed, and flows down through *g*, into *n*, and the vapours of the spirit pass into the refrigeratory, where they are also condensed, and flow out into the receiving can. The quality of the spirit is determined by the temperature at which the water is kept, in which the dephlegmator or alcogene is plunged. If this temperature is 130 or 136 deg. Fahr. the spirit will be of the strength three-five or three-six.

When the phlegm which separates from the alcohol, and runs into the receiver, *n*, appears to be totally exhausted, it is no longer pumped into the still bodies, but rejected as useless; and a fresh parcel of wine is let into the bodies, by turning the cock, *b*, and thus the distillation is continued without any interruption until the vinasse in the still bodies becomes so loaded with tartar and colouring matter, that there is danger of its furring them, and hence it must be let out by the discharge cock, *r*, and the bodies washed by pumping warm water into them.

Comparative trials were made with this apparatus, and those used by other distillers. Six cwt. of wine distilled in the stills of Messrs. Argand, and in stills constructed upon M. Chaptal's principles, yielded in nine hours, from one-fifth to one-third their weight in brandy, à preuve de Hollande. In the same space of nine hours, Dr. Solimani's apparatus converted 105 cwt. of wine into one-sixth its weight of spirit at three-six, with the expenditure of 3 cwt. of fuel. So that in an equal time, and with two-thirds of fuel, Solimani's apparatus distilled 18 times as much wine into strong spirit as the best common stills could convert into ordinary brandy.

It owes this advantage to the flat form of the dephlegmator, which exposes a thin sheet of vapour, in a horizontal position, to the cooling action of the water. A dephlegmator composed of four sheets of copper, only 18 inches square, and placed so close as to take up only 26½ inches in height, rectified, in 16 hours, 600 veltes, 17½ lbs. each, of brandy into strong spirit.

Fig. 221

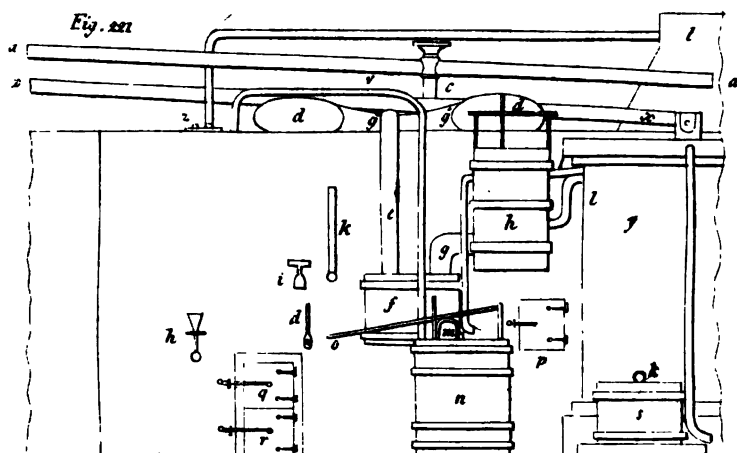


Fig. 222.

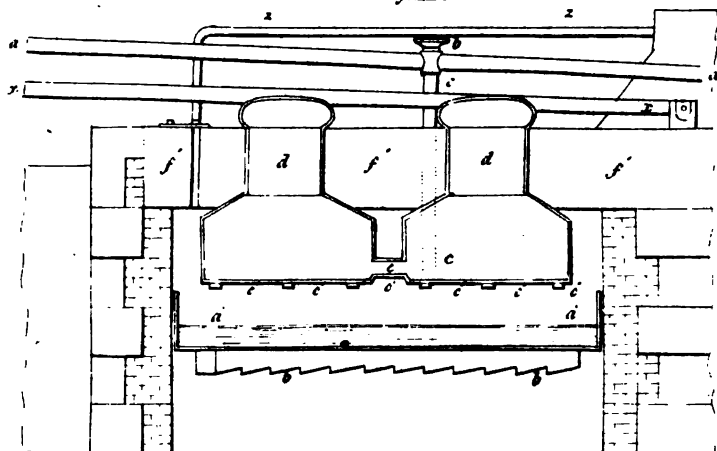
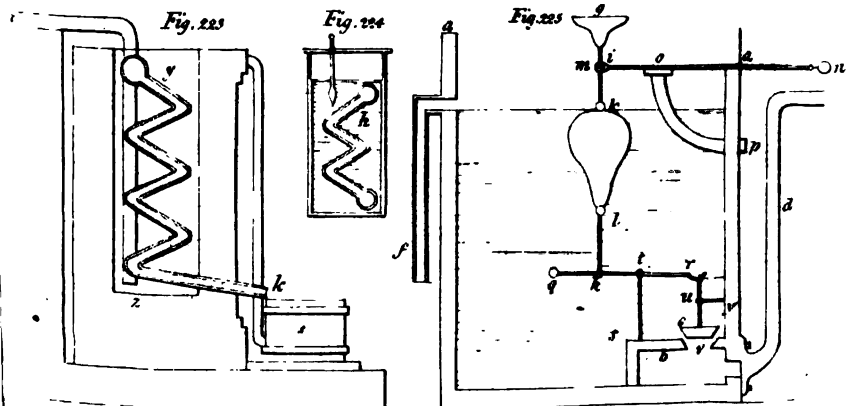


Fig. 223

Fig. 224

Fig. 225





As the steam is worked at the usual pressure of the atmosphere only, the heat communicated to the liquor in the still bodies is never entirely equal to that of boiling water; and, owing to this circumstance, the flavour of the spirit is so good as to make a difference of 5 per cent. in the price. M. Chaptal's report mentions the adapting of a loaded safety valve to the boiler, to work with hotter steam; but this would require additional apparatus, and, probably, diminish the fine flavour of the spirit by raising the essential oil of the grape.

Fig. 218, represents the apparatus of M. Berard. *A*, is the furnace in which the body of the still, *b*, is set. *C*, is the head; the dotted lines in the top of the still body and in the head represents the diaphragms with their condensing pipes and safety pipes; the construction of which are shown more at large in fig. 219. *D*, is the beak of the head, which is made very large, and furnished with two cocks, *k*, *i*, both of which have double passages. *E*, is a pipe proceeding from the beak to the hither end of the lowest branch, *x*, of the condenser. *F*, is another pipe proceeding from the beak, but ending in the hither end of the highest branch, *v*, of the condenser. *G*, is a pipe proceeding from the lower cock, *i*, of the beak to the farther end of the highest branch, *v*, of the condenser. *H*, is a similar pipe the farther end of the lowest branch, *x*, of the condenser. *I*, is a large cock with a double passage, by the turning of which the vapours are directed through the pipes, *g*, or *h*, either into the highest or lowest branch of the condenser at pleasure, or these passages are entirely stopped. *K*, is another large cock with two ways; by turning of which the vapours are either allowed to pass on to the end of the beak, or forced through the pipe, *f*, into the hither end of the upper branch, *v*, of the condenser. When *k* allows the vapours to proceed along the beak and the cock, *i*, is turned so that the passage into either of the pipes, *g*, or *h*, are stopped, the vapours are forced by the pipe, *e*, into the hither end of the lowest branch, *x*, of the condenser. *L*, is the pipe which conveys the uncondensed vapours from the lowest branch, *x*, of the condenser to the first worm. *M*, and *n*, is the pipe that connects the first and second worm. *O*, is a tinned copper vessel, in which the first worm is placed; this vessel is filled with the wine that is next to be distilled, and is closed at top, but has a pipe, *f*, not fully expressed in the figure, which, by means of branches and cocks, conveys at pleasure the vapour into any of the four ends of the condenser. *P*, is an open tub containing the water in which the second worm is placed; this tub serves as a support for the trough of water in which the condenser, *v*, *x*, is sunk, and entirely covered. *Q*, is the vessel which receives the spirit from the lower end, *r*, of the second worm. *S*, is the fire door of the furnace. *T*, is the ash room door. *U*, is the pipe that conveys the phlegm condensed in the condenser back into the body of the still. *V*, is the highest branch, and *x*, the lowest branch of the condenser, as it lies sloping in the trough of water, to allow the condensed phlegm to run from the end, *f*, to the end, *e*.

This condenser, of which a bird's eye view is given at fig. 220, and marked with the same letters, is composed of two branches, *v*, and *x*, and an intermediate piece to join them. The branches are three feet long and six inches in diameter; the intermediate piece is only 18 inches long, so that the branches are that distance apart. The condenser is divided internally into 13 parts by partitions, which have each of them a round hole on the side alternately right and left to allow the vapours to pass from one partition to another, and a semicircular hole in their lowest part to allow the condensed phlegm to run from those that lie the highest into the others, and from thence into the pipe, *u*. The water with which the condenser is entirely covered, is kept at 122° Fahrenheit.

Y, is a pipe with a cock by which the wine in *o*, is conveyed into the body

of the still when a new distillation is to be begun. *Z*, is a short pipe with a screw stopper, by which, when a course of distillation is first begun, a little wire is introduced to lodge upon the diaphragms in the head and body of the still, in order to ensure the immediate action of this apparatus. *A* is a pipe with two cocks, to pass the phlegm condensed on the diaphragm in the middle of the head into the lower part. *B* is a similar pipe, to pass the phlegm condensed on the diaphragm in the upper part of the still body into the lower. *C* is the lower cock of the pipe, *B*, and has two ways, in order that it may show when the body of the still is sufficiently filled with wine. *D* is the discharge cock of the still body. *E* is the gauge cock of the wine vessel, *a*, to show when it is full. *F* is the beginning of the pipes from the vessels, *a*, to the condenser. *G* is a short pipe with a screw stopper, by which the vessel, *a*, is filled. And *H* is a similar pipe by which the body of the still is filled.

Fig. 219, represents a section of the diaphragms in the head and body on a larger scale. *A*, is one of the condensing pipes, six inches long and two wide. This is covered with a cap, *b*, of the same length, but three inches wide, and supported by three fastenings at about half an inch from the diaphragm. *D*, is one of the safety pipes, a foot long, soldered in its middle to the diaphragm. The lower end has a cap similar to those that cover the condensing pipes, and the upper end is pierced with two rows of holes, the lower of which are about three inches above the diaphragm. Each of the diaphragms has a safety pipe in the centre, and three condensing pipes in the circumference: but if the still is made larger, more condensing pipes must be used, and the safety pipes increased in proportion.

The gauge cock, *e*, being left open, wine runs into the still body by the pipe *H*, through a funnel until it runs out at the gauge cock, *e*. Some wine is poured in at the pipe, *z*, to lodge on the diaphragms in the head and body of the still. The vessel *a* is then filled with wine by the pipe *g*, until it runs out by the gauge cock, *e*. The trough in which the condenser is placed is filled with warm water at 122° Fahr. and the cooler, *p*, with cold water.

The fire is then lighted, and the distillation begun as quickly as possible. If the strongest spirit that the apparatus will yield is to be obtained, the cock, *k*, is turned so as to prevent the vapour from proceeding farther along the beak, and to force it through the pipe, *f*, into the condenser. The vapours of the wine are thus obliged to pass through the wine on the diaphragms in the body and head of the still, by which some of the watery vapours are condensed, and flow back again through the safety pipe into the still body. The uncondensed vapours then pass along the beak, and are forced through the whole length of the condenser, *v*, *x*, which, being kept at the uniform temperature of 122° Fahr. condenses the greater part of the watery vapours which flow back into the still body by the pipe, *u*, and allows those of the spirit to pass into the worms by the pipe, *l*, and from thence into the receiver, *q*. If a spirit of less strength is required, the cock, *k*, is turned to shut the pipe, *f*, and allow the vapours of the wine to pass along the beak to the cock, *i*, which is turned so as to pass them through the pipe, *g*. In this case the vapours pass only through the intermediate and lowest, branch, *x*, of the condenser; and less of the watery vapour being condensed therein, the remainder passes along with the vapour of the spirit into the worms. If still weaker spirit is only required, the cock, *i*, is turned so as to force the vapour through the pipe, *h*, and of course through the lowest branch, *x*, of the condenser. Lastly, if it is intended to obtain a very weak spirit, the cock, *i*, is shut, and *k*, opened so as to send the spirit through the pipe, *e*, into the last partition only of the condenser.

The spirit that flows into the receiver is examined from time to time, and when the distillation of a charge is finished, the fire is withdrawn, the wine runs out by the discharge cock, *d*, and the body charged afresh, by opening the cock, *y*.

The cocks on the pipes, *a*, *b*, are only opened when it is apprehended there may be more phlegm on the diaphragm than can run off by the safety pipe. They seem to have been used in the stills made before the invention of the safe-

Fig. 226

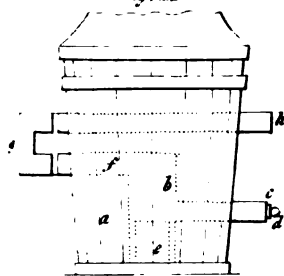


Fig. 227

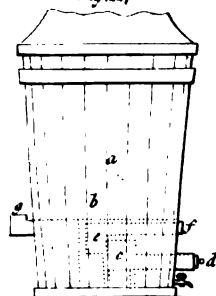


Fig. 230

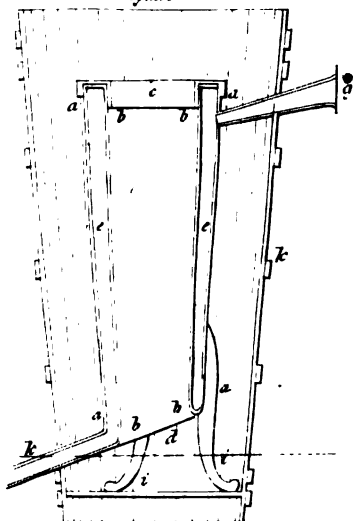


Fig. 228

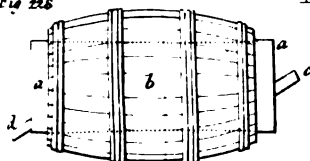


Fig. 229

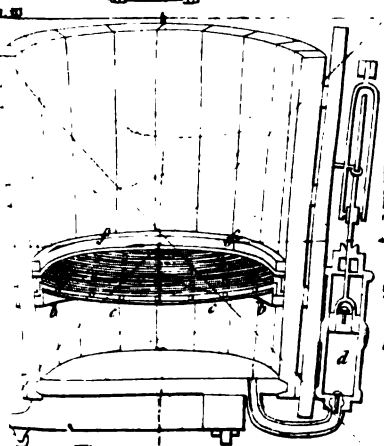


Fig. 229

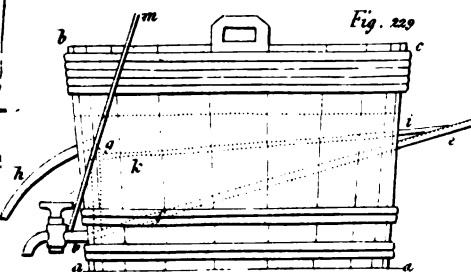


Fig. 234

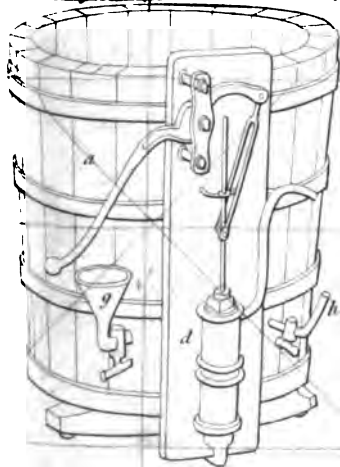


Fig. 231

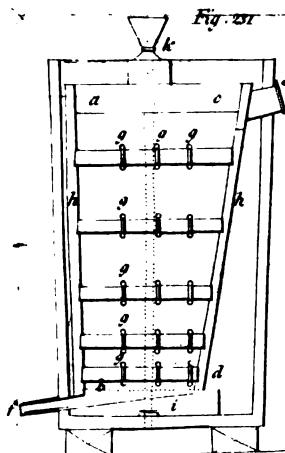
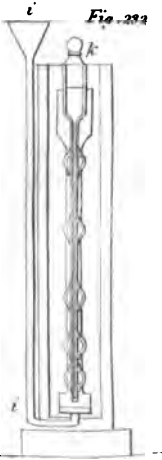


Fig. 232





ty pipes in the diaphragms, but are now a needless incumbrance; and a simple gauge cock at *c*, is all that is necessary.

Ten veltes of Touraine white wine, one of the worst wines to distil, yielded, on a public trial, spirit of any required strength at pleasure, and these different parcels mixed together made up 1 velte, seven-eighths of brandy, á preuve de Hollande, with 2 degrees of surforce. This brandy put into the still yielded, on a second trial, the whole of its alcohol, in spirit three-eighths, the strongest that is kept for sale. The two trials occupied 2 hours. In the common mode Touraine white wine yields one-eighth less brandy, and that not full proof.

Cogniac Brandy, or best Spirit of Wine.

This is obtained by distilling the palest white wines in the ordinary still by a gentle heat, so as to avoid raising the essential oil contained in the skin of the grape.

It may also be obtained by distilling other white wines, or even the paler red wines in Solimani's apparatus.

It is sometimes kept in glass bottles, or stone ware vessels for sale, in order to prevent its tasting of the cask, or acquiring a colour, and to retain its flavour of musk; but this retards its getting rid of the fieriness of new brandy.

Inferior Brandy, or Eau de Vie de Marc.

This spirit is known by the hot fiery taste of the essential oil of the grape, with which it is impregnated. It generally sells for one-fourth or one-third less price than that of ordinary brandy. It is drank by the lower class of people in France, and preferred by the English and other northern nations, on account of its taste being similar to that of the hot oily kinds of spirit made by them from corn, potatoes, and other substances.

It is made by distilling the dark red wines of Portugal, Spain, and other countries; as also the lees deposited by wine on keeping, the scrapings of wine casks, the skins or grains of common raisins deposited in the making of raisin wine, the cake left in pressing grapes, and the lees left in making vinegar.

The distillation of the wines is performed as usual, but as the taste of the spirit is not regarded, it is hurried on fast.

The cake left on pressing grapes is prepared for distillation by being broken to pieces, and thrown into large covered tubs, water is then added, the mixture soon ferments, and when the fermentation is complete the liquor is distilled in the ordinary

stills. The produce of the first distillation is of a whitish colour, and hence called *blanquette*, this is distilled again; and yields a spirit at 22 or 24 deg. Baumé. It takes 84 or 85 pounds of the grape cake to produce one pound of brandy.

In some places, the grape cake is broken, flung into pits, and covered with earth; the process of the fermentation is judged by thrusting the arm into the heap. When ready, it is taken out of the pits, mixed with water, and distilled. In this manner, 90 or 100 pounds of grape cake are required to yield a pound of brandy.

These liquors are peculiarly apt to burn to the bottom of the still, and hence to have the taste of the spirit still more depraved by the addition of a smoky flavour. Several attempts have been made to avoid this inconvenience. Devanne proposed stirrers to keep the liquor in continual agitation, and prevent the sediment from adhering to the bottom of the still; but this requires a complicated form to be given to the still. Some distil their wine lees in a water bath, and Baumé used a basket to be placed in the still body, into which the thick liquor was poured, and thus the sediment was retained in the basket. The vinegar makers at Paris drain their lees, and when no more liquid will run, put the remainder into sacks, and press out the liquor, which is mixed with the former, and distilled.

M. Reboul has established a distillery for grape cake. His still bodies are large wooden casks, to which are adapted worms, of the usual form, and he heats the thick liquor by introducing steam into it from a boiler, placed in the centre of his still house.

M. Curaudau distils wine lees in a still whose neck is a separate piece, as wide as the still body, and three feet long; brackets are made on the inside, to support several partitions, at nine inches apart. Each of these partitions have several small short pipes, to allow the vapours to pass freely, and are pierced with a number of small holes. The neck being put in the still body, and the lowest partition put in, some of the wine lees are poured in, the liquid part drains into the still body, the thick part remains on the partition; another partition is then put in, and more lees, and so on, until all the partitions are covered, about six inches deep with the thick matter of the lees. If the liquor that drains from them is not sufficient to fill the still body, water is added. The distillation being begun, the steam heats the several layers, and causes them to give out their spirit.

As most of these liquors contain an acid that unites with the essential oil of the grape, and depraves the taste of the spirit,

it is proper to add limestone to separate this acid; or, which is still better, quicklime, which will also absorb some of the oil.

The thick grouty matter left in these distillations, or the cake left on pressing the lees, is dried and burned for its alkali, which is sold by the name of *cendres gravellées*, and is esteemed by the French dyers as preferable to potash or pearl-ash.

The physeter of Mr. Field, would be very useful in the manufacture of common brandy from these grouty materials.

Fig. 233, represents a section of the physeter, or percolator; and fig. 234, is the elevation of the same. *A*, is a strong tub, with iron hoops, moveable upon castors. *B*, is a wooden hoop, fixed on the inside, a few inches from the bottom. *C*, is a strainer, resting upon the hoop, *b*; that represented in the figure is a sieve of copper wire. *D*, is a small lifting pump, placed on the outside of the tub, and communicating with the lower part. *E*, in the side figure, shows the copper sieve, covered first with a baize strainer, and over that another of the silk called lute-string, to show how the edges of these are secured by being turned over the rim of the strainer; the space left between them and the side of the tub, is secured by a list of woollen cloth, and the whole fastened down by the hoop, *f*, which fits so closely to the sides of the tub when driven down, as to render the whole air tight. *G*, is a funnel cock, by which the lower part of the tub may, if required, be filled with water. *H*, is another cock, by which the air in the lower part may be let out while it is filling with water, by the cock, *g*; or the air let in it, if the purpose for which it was exhausted by the pump, is answered.

Sheets of filtering paper may be placed between the cloths of the strainer, or the number of these may be increased; and if a copper wire strainer is judged improper, a wooden grating may be substituted.

As the action of the pump occasions the atmosphere to press upon the surface of the liquor, at the rate of 14 pounds to every square inch of surface, this apparatus is very powerful in forcing liquids through several layers of filters, or filtering powders, or in draining the last portions of liquor from spongy substances, which would otherwise retain a large portion of the liquid with which they are impregnated.

Potato Spirit.

The potatoes best adapted for distillation, are those that contain the most fecula; of which, in an average, they contain one quarter of their weight. It was a great inconvenience in their use, that they could at first only be employed from October to May; but means have now been found to avoid this defect.

The first method is, to boil the potatoes by steam; this is done in France, a ton weight at a time, in one hour, and they are then reduced to a mash, in the same time.

In a working tun capable of holding at least 350 gallons, there

are put 8 cwt. of the mashed potatoes, and $\frac{1}{2}$ cwt. of malt, with a sufficient quantity of hot water, that the heat of the mash may be 95 deg. Fahr. and the whole is well stirred. In half an hour, more boiling water is added, to raise the heat to 131 deg. Fahr. Two or three hours afterwards, hot and cold water is added, so that the heat may be 77 deg. Fahr. and the mash made up to 300 gallons. A quart of good beer yeast is then added, which produces the necessary fermentation, and when this is perfected, the whole is put into this still. In this method, it requires the particular apparatus already described, to prevent the spirit from acquiring a bad flavour, by the seculent matter adhering to the still.

The second method is, to put 8 cwt. of raw potatoes, grated to a pulp in a mill, into a mash tub of 200 gallons, with a false bottom and straw between the bottoms. In half an hour, the water that has run from the pulp, is let off, and about 120 gallons of hot water is added, as also $\frac{1}{2}$ cwt. of malt, and the whole well stirred. In three or four hours, the clear wort is drawn off into the working tun, which need only contain 280 gallons. Fifty gallons of hot water are then added to the potatoes, and this being drawn off, another 50 gallons of cold water is poured on the potatoes, drawn off, and added to the warm mash, which it cools to the proper temperature; and this is fermented with yeast, and distilled as usual.

The pulp retains about three-fourths its weight of wort, which might be extracted by the press; but it is usually left, to render the pulp better for the animals who are fed upon it.

The third method, invented by Kirchoff in 1811, is to convert potato starch into syrup by oil of vitriol. For fermenting 6 cwt. of potato starch, the mashing tub, which must be lined with lead, should contain 500 gallons, be covered at top, except a trap, furnished with a stirrer, having several wings, and two discharge cocks, one even with the bottom, the other about six inches above it: 150 gallons of water are put into this tub; and steam being conveyed into it from a boiler, by a leaden steam pipe, it is brought to 176 deg. Fahr. In the mean time, 6 cwt. of potato secule are mixed in another tub with 12 cwt. of water, and 12 pounds of oil of vitriol; and this liquor is introduced at three or four times by the trap, into the hot water in the working tub, taking care that the water be brought to its original heat, before a fresh parcel is added, and also to heat it to that point at the end. The trap is then closed, and if it does fit well, is luted round with clay, and the whole left for six hours, care being taken to prevent its cooling too much; a glass of the liquor being then drawn off, tincture of iodine is added, and if a blue colour is produced, the sacchari-

fication of the fecule is not completed, and the whole must be left for some time longer, and again assayed. The trap being then opened, the oil of vitriol is neutralized by adding gradually about 20 pounds of whiting, previously made into a liquid with seven or eight gallons of water. The neutralization is assayed by dipping a slip of litmus paper into the liquor; as long as it is turned red, more whiting must be added. The liquor is then left for about an hour to settle, when it is drawn off clear by the upper discharge cock, and let into the fermenting tub. The sediment is let out by the lower cock, and thrown upon canvas filters; the liquor that drains from it is added to the other, and fermented with yeast, and distilled in the usual manner.

The fourth method, discovered by Cadet Gassicourt, in 1817, differs only from the former by using steamed potatoes, reduced to pulp, instead of potato starch.

A fifth method, totally different, has been invented by Mr. Siemen, of Pyrmont, and has been adopted in Sweden and Denmark. The potatoes are heated by steam, and broken down by a revolving iron cross, much finer than by pestles or a rasping mill. The pulp is then mixed with hot water, and to each ton weight of potatoes is added a pound of potash, rendered caustic by quicklime. The pulp is cooled as quick as possible, and to each three tons of potatoes, is added half a ton of malt, and the whole fermented as usual. This fermentation produces a very large quantity of excellent yeast, so as to allow a profit to be also made by its sale.

The sixth method was invented to get rid of the trouble of reducing the potatoes into starch, and yet preserve them fit for distillation all the year. The potatoes are steamed and reduced to a pulp, which is spread about an inch thick upon flat wicker baskets, which are placed one upon another, in an oven or stove, until the pulp is perfectly dry. The dried pulp is kept until wanted, when it is ground, sifted, and reduced to saccharine matter either by oil of vitriol or caustic potash, as in the former methods, fermented with malt, and afterwards distilled.

Potatoes ferment quicker than corn, the mash being usually brought to the specific gravity, 1.036 to 1.044, and do not require so much yeast to be added. Sometimes the pulp of the potato forms a dry head over the liquor, and does not allow any yeast to pass, but the fermentation goes on equally well.

Beet-roots or carrots steamed and ground with the potatoes, improve the flavour of the spirit.

Thirty-eight cwt. of potatoes, with 200 gall. of malt, yield about 225 gall. of spirit.

M. Oerstedt removes the green taste of potato spirit, by

adding about an ounce of oxymuriate of lime to each 10 gallons of spirit, and re-distilling it. As the strength of oxymuriate of lime, called also bleaching powder, is very variable, it is necessary to make a trial or two in a small assay still, before mixing any large quantity.

Malt Spirit, or Whiskey.

This is generally prepared in England at present, by mixing 3840 gallons of rye or barley, ground very fine, and 1280 gallons of coarse ground pale malt, and making it into a mash, with 8500 gallons of water, heated to 170 deg. Fahr. There is then drawn off 1020 gallons of this wort, and a large quantity of yeast is added to it: and when the remaining wort is cooled down to 55 deg. Fahr. 80 gallons of malt are mashed with another portion of 1020 gallons of hot water, and this being drawn off, is mixed with the first wort, and the yeasted wort is also added. This wash should have the specific gravity from 1.084 to 1.110. In the course of ten or twelve days, the specific gravity gradually diminishes till it becomes only 1.002 when the yeast head falls quite flat; the wash has a vinous smell and taste, and is fit for the still. It is calculated that every 64 gallons of meal and malt ought to produce 18 gallons of spirit, so much stronger than proof spirit, that 10 gallons will make 11 gallons proof, or about 1782 gallons of proof spirit in the whole.

In general, one-third of the wash is drawn over at the first stilling, and the product is called low wines, the specific gravity being about 0.975. On re-distilling the low wines, a milky, fiery tasted spirit comes over at first; when the running turns clear, the spirit that has come over is returned into the still. The distillation being continued, the clean spirit comes over; and when the running gets below a certain specific gravity, the remaining spirit which comes over, until it ceases to be inflammable, is kept apart, by the name of faints, and is mixed with the next parcel of low wines that are distilled.

The proportion of malt to the raw grain is sometimes diminished much below that stated, even as low as only one-tenth of the raw grain.

If the wort is not sufficiently heavy, its specific gravity is brought up by adding a strong infusion of ground malt, or barley and malt.

The fermentation is generally carried on in open pits, and hurried as much as possible; but of late, some distillers, considering that the carbonic acid gas carried off much of the spirit, have covered the pits with a flooring, having a trap with a water joint, to prevent the loss of the spirit: this retards the fer-

mentation, but the augmentation of the produce, although slight, is judged fully equivalent to the loss of time.

The Dutch distillers make their wash much weaker, so that it does not weigh more than 18 pounds, by the barrel of 34 gallons, more than water, and use a much less quantity of yeast than our distillers. They also attach much importance to the quality of the water: and so highly esteem that of the river Meuse, that the capital distillers keep sailing lighters in constant employment to fetch water. And as they are not restrained, they use for their best corn brandy two-thirds of wheat meal, and one-third of rye meal. The latter being added, because its infusion ferments better than that of wheat.

West India Rum.

It is manufactured on the sugar plantations, by taking equal quantities of the skimmings of the sugar pans, of the lees, or returns, being what is left in the still in a former distillation, and of water; and to every 10 gallons of this mixture is added a gallon of molasses. When this is properly fermented, each 100 gallons affords about 15 gallons of proof rum, strongly flavoured with the essential oil of the sugar cane, and twice as much low wines, or weak spirit, to be redistilled.

In Jamaica the rum is sometimes rectified to a strength nearly equal to that of alcohol, and is called *double distilled Jamaica rum*.

Molasses Spirit, or Common Rum.

This spirit is manufactured in England, by mixing 100 gallons of molasses, or treacle, with 300 gallons of water, and 2 gallons of yeast. Once or twice a day, the head as it rises is stirred in, to encourage the fermentation; and on the third or fourth day 200 gallons more water are added, and 2 gallons more yeast. In another four or five days another 2 gallons of yeast are added, on which the fermentation proceeds with great violence, and in three or four days the wash will be found no longer to diminish in specific gravity, and of course to be fit for the still.

Each 100 gallons of this wash is computed to yield 22 gallons of spirit, 10 gallons of which are equal in strength to 11 of proof spirit.

Cider Spirit, or Apple Whiskey,

Is obtained from wash made of bruised apples, pressed. Each 100 gallons of the fermented juice is computed to yield about 16½ gallons of proof spirit. It is much drank in the United States.

Raisin Spirit,

Is manufactured for the purpose of giving a brandy flavour to malt spirit. To each cwt. of common raisins are added 34 gallons of water, and after two or three days some yeast is added. When the liquor no longer diminishes in specific gravity, the whole is put into the still and distilled with a quick fire, to bring over as much as possible of the essential oil of the fruit.

One gallon of this spirit will give a sufficient flavour to 160 gallons of malt spirit, to enable it to pass for brandy amongst those unaccustomed to the genuine article.

The strength of spirit is estimated in England, as in France, by expressing the quantity of water that must be added to strong spirit to reduce it to a certain arbitrary strength, called proof spirit, or the quantity of water that is contained in excess in any weak spirit.

The following table shows the specific gravity of spirits of the various strengths as indicated by Clarke's hydrometer, at the temperature of 60 deg. Fahr.

Under proof.		Over proof.	
1 in 2	— 9644.	1 to 20	— 9162.
3	— 9543.	15	— 9135.
4	— 9458.	10	— 9107.
5	— 9424.	9	— 9093.
6	— 9385.	8	— 9071.
7	— 9364.	7	— 9047.
8	— 9344.	6	— 9006.
9	— 9334.	5	— 8961.
10	— 9320.	4	— 8913.
15	— 9280.	3	— 8817.
20	— 9265.	2	— 8590.
Proof spirit	9200.	Alcohol	8338.

When spirit is diluted with water, the essential oil it contains frequently renders the liquor cloudy; a little alum in powder mixed with an equal quantity of sub-carbonate of potasse, is usually added to restore the transparency, but the means which has succeeded the best is the solution of white sugar in cold water, mixed afterwards with the spirit, and some white of egg beat up with it. Three or four days are generally sufficient for the complete depuration of the liquid. The sediment which is formed is very considerable, and the liquid easily passes through filters.

Isinglass was used in this operation, and also milk and cream; but the latter are never so limpid nor so free of colour as those

which are treated with white of egg. They also have an oily aspect, and do not pass through filtering paper without the greatest difficulty; and milk and cream also injure the taste of the finest spirits and liqueurs.

The excellence of French brandy depends not only on the material from which it is distilled, but also on the care that is taken to keep it from the contact of any thing that may deteriorate its flavour, by distilling it in well tinned stills, and thus avoiding flavouring it with the taste of copper. The distillers of malt spirit, or potato spirit operating upon an inferior material, have not an equal interest in preventing their spirit from acquiring a foreign flavour; hence they not only employ untinned copper stills, and worms, but have even attempted to distil in wooden vessels.

Fig. 226 represents a wooden tub, as fitted up by M. Fischer, in Denmark, and used there upon a large scale. *A* is a tub or tun of a very large size, strongly bound with iron hoops, being the body of the still, and to which there is fitted a tin copper neck, head, and worm, of which the first only is shown in the figure. *B* is a square fire room of sheet copper, tinned on the outside, and placed in the middle of the tub; the entrance to which is a square pipe, *c*, which passes beyond the tub, and serves to introduce the fuel: this pipe is closed by the door, *d*. *E* is the ash room, the bottom of the tub being cut out to allow the ashes to fall through. *F* is the copper pipe, tinned like the rest on the outside, that serves as the chimney, and passes through the side of the tub. *G* is a part of the chimney on the outside of the tub, and *h* is another part that passes through the upper part of the tub. The wash is thus heated by a fire made within the tub. All the places where the pipes belonging to the furnace enter the tub must be carefully stopped.

Fig. 227, represents a water bath of a similar construction, devised by M. Fischer for the rectification of the spirit. *A*, is a large tub bound with iron hoops. *B*, is a copper bottom, tinned on the upper surface, and so perfectly adjusted with the sides of the tub, so that the liquor on the upper part may not filter in any manner in the lower part. *C*, is a fire room, like that of the former apparatus. *D*, is the fire room door. *E*, is the chimney, which turns forwards and comes out of the side of the tub at *f*. *G*, is a bent pipe which serves to fill the lower part of the tub with water, and allows a passage to the steam, when the water is heated to that degree which is most favourable for the re-distillation of the spirit with which the upper part of the tub is filled; although towards the end it is necessary to augment the heat.

Fig. 228, represents the condensing apparatus adapted by M. Fischer to these wooden stills, and which was the first example of increasing the size of the worm. *A*, is a large copper cylinder fixed in a barrel, *b*, which is kept filled with cold water by means of a pipe. This cylinder stands out about three inches from each head of the barrel. *C*, is the short pipe at one end of the cylinder, into which the beak of the still head is inserted; and *d*, is the pipe through which the condensed spirit flows into the receiving can.

Fig. 229, represents another apparatus proposed to be substituted in the place of the common worm, as not costing more than one-tenth of the price of the worm, and being much more easily manageable. *A*, *b*, *c*, *d*, is a large open tub filled with water. *E*, *f*, is a tinned copper pipe, which enters into the tub at the hole, *i*, at about half its depth, and is connected at the end with a cock,

L, *F*, *g*, is a pipe which passes perpendicularly to the same height as *i*, in the inside of the tub, and being there bent passes out of the side as at *h*. *I*, *k*, is a pipe of a very small bore, that joins the two other pipes, *e*, *f*, and *f*, *g*. *L*, *m*, is a glass pipe cemented into the neck of the cock belonging to the pipe, *e*, *f*; this glass pipe, or barometer tube, is on the outside of the tub, and supported in its place by stays. All these pipes open into one another.

The end, *e*, of the pipe, *e*, *f*, being adapted to the beak of the still head, and the cock, *l*, closed, the first portion of liquor that is condensed, fills the several pipes to the level of *g*, after which they run off by the pipe, *g*, *h*. The pipe, *i*, *k*, being intended only as a safety pipe is necessarily of a very small bore, as otherwise the vapours might pass along it and escape without being condensed. The point, *i*, where this pipe is soldered to the pipe, *e*, *f*, ought to be a quarter of an inch above the level of the bend, *g*, and the point, *k*, where it is soldered to the upright pipe, *f*, *g*, ought also to be a quarter of an inch below the level of the bend, *g*; in order that the vapours may suffer no other pressure than that of the column of liquor, *g*, *m*. The use of the cock, *l*, is only to empty the pipes, and allow the pipe, *e*, *f*, to be cleaned. The glass pipe, *l*, *m*, is merely to show the height of the liquor in the pipe, and they indicate whether the whole apparatus acts properly.

The distilleries in Sweden being a crown manufacture, the commissioners to whom they are intrusted have an opportunity of making extensive experiments on the best construction of the apparatus.

Fig. 230, represents the section of the condensing apparatus introduced by Mr. Gedda, which consists of two concentric inverted truncated cones, one within another, at a few inches distance; in which interval or void space, the condensation of the vapour is effected by the cold water surrounding the outer cone, and filling the inner cone. *A*, is the outer cone, and *b*, the inner cone, both of which are made of copper, and the surfaces next each other well tinned. *C*, is a copper ring which closes the space between the cones at top. *D*, is a similar ring to close the space at bottom. These rings are well soldered to the cones, and allow a free passage for the water to the inside, *f*, of the inner cones. *E*, is the space between the cones, in which space the vapours are condensed. *G*, is the pipe which conveys the vapours from the still head to the space, *e*, between the cones; and *h*, is the pipe conveying the condensed spirit to the receiving can. *I*, are the three feet which support the condenser within the tub, *k*, which ought to rise at least two feet above the condenser, and be supplied with cold water from below. The warm water that rises to the top, may be drawn off for use as wanted.

The condensers that have been made for the largest stills used in the royal distilleries of Sweden being stills of 600 gallons, and 5 feet in diameter, have the outer cone 34 inches wide at top, and 21 at bottom, and the inner cone 27 inches wide at top, and 19 at bottom, and their height 7 feet; the distance between the two cones at the upper end is 3½ inches, and at the lower end 1 inch; the cooling surface is about 80 square feet, and the content of the cooling space about 50 gallons. The price of a condenser of this kind is only half that of a worm fit for a still of the same capacity.

A still of only 2 feet diameter, or 32 gallons, requires only 10 square feet of cooling surface, and the distance between the cones at the top need only be 1½ inch, and at the bottom half

an inch. Some regard must be had to the usual size of the copper plates, that no unnecessary soldering may be necessary.

Fig. 231, represents the elevation of a condenser constructed by M. Notberg, in the Royal Distillery of Sweden, under his care. This condenser is formed of sheets of copper, formed into a chest placed on one of its ends, the height, *a, b*, being seven feet, the breadth at top, *a, c*, four feet and a half, and at bottom, *b, d*, two feet and a half. The sheets of copper at the upper part are about seven inches apart, for the convenience of receiving the vapours from the still body through a short pipe, *e*, of six inches bore, but below the entrance of this pipe between the sheets, they are only two inches asunder. At the bottom of the chest is a pipe, *f*, to convey the condensed spirit into the receiving cans.

As the sheets of copper, of which this condensing chest is formed, ought to be rolled very thin, and hence from their weakness might be crushed together by the pressure of the water in the tub in which it is placed, several rows of strong rings, *g*, are soldered to the front and back sheets, through which bars of wood are thrust, and kept at the proper distance by two standards, *h*, on the sides, which also serve to keep the condenser in its proper position in the tub. The tub, or rather cistern, is adapted to the form of the condenser, so as to leave about nine inches of water all around it, so that it is internally about nine feet high, five feet wide and only one foot and a half from front to back. The cold water is conveyed into it by a pipe, *i*, entering at the bottom, and the warm water runs out at the top by a spout. A wide pipe, *k*, is soldered in the middle of the top of the condenser, that it may be cleaned, and this pipe is at other times kept close by a plug.

This condenser is very similar to the dephlegmator, or alcogene of Prof. Solimanni, but is not placed so advantageously, and it would condense the vapour much more rapidly if it were placed with its broad surfaces in a horizontal position, in a shallow cistern of water about 2 feet deep.

Alcohol.

This is the strongest spirit, that can be made, and is usually prepared by rectifying the common spirits over potash, muriate of lime, or quicklime, but since these additions partly change the nature of the spirit, M. Hermbstadt observes, their utility in distillation is not such as has generally been supposed. M. Duebac has tried a variety of substances, the principal of which were, burnt stucco, calcined Glauber's salts, common salt heated, and potters' clay, of which the last appeared best to answer the purpose. To 12 ounces of clay, well washed, sifted and strongly dried, M. Duebac applied 32 ounces of spirit of wine, at 39 deg. Baumé, or sp. gr. 0.832, which on being distilled yielded alcohol of 42 deg. Baumé, or the spec. grav. 0.820; and which, on being re-distilled with potters' clay, became no lighter, whence M. Duebac looked upon it to be pure alcohol, whereas, that obtained by the application of potash and muriate of lime may be brought to 50 deg. Baumé, or the spec. grav. 0.782; but this seems owing to

the formation of ether. M. Hermbstadt asserts, that by simply distilling brandy six times without having recourse to any substance for the purpose of divesting it of its aqueous parts, he has obtained alcohol, spec. grav. of 0.800, or 46 deg. Baumé, of course it was lighter than that which M. Duebac purified by means of potters' clay.

ETHEREAL OILS.

These are distinguished from other oils by their being distillable with little or no alteration by a heat not exceeding that of boiling water, or at least, that of boiling sea water.

They are most generally obtained by distilling strongly scented vegetables with water; but a few are obtained by other processes; some are collected in the cells of plants, and require only pressure, or the cell to be laid open by a hatchet, to flow out, as the essence of lemons, laurel oil, Sumatra camphire, and liquid camphire.

Essential Oils of Plants.

The plants from which ethereal oils are to be distilled should be collected at the time when their scent is most powerful; and in most instances it is preferable to dry them previous to distillation, to get rid of some of the acid juices of the sap of the plant, which, by enabling the water with which they are distilled to dissolve more of the oil than it otherwise would, would diminish the produce. This drying is still ordered by the Pharmacopœia to be made in the shade, notwithstanding the sarcastic remarks of Culpeper in his notes to the first edition of that work. He directs the physicians of the College to inquire of the farmers whether their hay is not best got up in the hottest sunshine. The frequent turning of plants drying in the sun is necessary, and it was only to avoid exposing themselves to the sun that the ladies, who were formerly the distillers of these oils, were directed to dry them in the shade. When sunshine is not procurable, the plants should be dried on a kiln as quick as possible.

Woods must be reduced to shavings, barks and similar substances reduced to a gross powder; and these, in general, require to be soaked for some days before they are distilled, in water acuated with salt, or even a little spirit of salt.

The copper still should be well tinned, that the oil may not be tinged by dissolving any of the copper in its passage. The body no bigger than will hold the substance and the water, that the oil may have less height to rise; and for the

same reason the moor's head is preferable to the swan-neck capital: the moor's head should be covered with a flannel cap kept moist, with a drip of water from a cask or jar placed above it.

No more water should be added than is necessary to bring over the oil, and prevent the matter from burning to the still: hence, the goods should first be floated with water, and then more added by weight or measure. In goods that yield their oil easily, about six times their weight is sufficient; but in others, which yield their oil with difficulty, as the woods, ten times their weight must be added.

The distillation is continued with a quick fire, until the quantity of water that was added is come over; and if the last portions bring over any oil with them, the fire is slackened, and the distilled water returned into the still, and brought over again: this is sometimes necessary to be repeated a second time.

The common spiral worm is by no means proper for distilling oils, unless in those manufactories where only one oil is made, on account of the difficulty of cleaning it, and the danger of thus mixing the scents of two or more oils together. The straight pipes, shown in fig. 8, are preferable, and still more the encased single straight pipe of fig. 7.

In distilling liquid oils, the condensing worm or pipes are kept as cool as possible; but there are some oils, as aniseed oil, which are apt to congeal in the condensing apparatus; and hence, this must be kept so warm as to prevent its congelation.

The quantity of oil which comes over being very small in comparison with that of the water, the spirit receiver of fig. 199, is most commonly used, which allows the water to pass off into another vessel, and retains the oil whether it floats on the water or sinks in it; or the Italian receiver of fig. 7.

The water which has been used in a preceding distillation may, in general, be advantageously used in a second operation with fresh goods, and sometimes a third; but by frequent cohobation the water becomes acid, and takes up the oil, thus diminishing its produce.

Roses must be distilled with their green flower cups, and tore open by the nails, as the liquid or scented oil is lodged in a cell at the claw of each petal. By adding a little spirit of salt to the water, and digesting for a few days, the produce was doubled.

Some of these oils, as those of aniseeds, chamomile flowers, caraway seeds, cassia buds as a substitute for oil of cinnamon, cinnamon, cloves, dill, juniper berries, mint, nutmegs, pennyroyal, peppermint, rue, sassafras, savine, and

wormwood, are used in medicine as carminatives and stimulants. Others, as those of aniseeds, caraway seeds, cassia buds, cinnamon, cloves, juniper berries, and pepper, in compounding the cordial waters of the spirit dealers. A third class, as those of balm, citron flowers, called *essence de cedras*, lavender flowers, broad leaved lavender, called *true oil of spike*, orange flowers, called *neroli*, roses, rosemary, sanders, or sandal wood, and thyme, called *huile de tain*, are used to scent spirits of wine, and form what are called waters for the toilet, as eau de Cologne, Hungary water, and the like, and which are used by the ladies of the upper class of society as cordials. Others, as those of balm, calamus aromaticus, chamomile flowers, caraway seeds, hysop, lavender flowers, marjoram, milfoil, parsley, rosemary, sage, sassafras, and thyme, to scent soaps.

Essential Oil of Bitter Almonds.

This oil requires particular treatment, 32 pounds of bitter almonds being taken and pressed to get out their fixed oil, the cake is to be ground to a coarse powder, and distilled with 8 wine gallons of water, until the whole is come over; about three-fourths of an ounce of oil will swim on the water, and is to be taken off. As much salt as the water will dissolve is then added to it, and about a gallon distilled off, which will bring with it nearly 4½ ounces more of oil.

The distillation of this oil ought to be made in the open air. In a common laboratory the operator, and indeed all in the house, will probably be disabled by the head-ache for several days. As the operator may faint during the process, a watch must be kept on him.

This oil is a poison of the quickest action, but being diluted with seven times the quantity of spirit of wine, it is used under the name of *essence of bitter almonds* by the confectioners and makers of liquors, to communicate the flavour of peach kernels.

Oil of Turpentine.

This is also frequently called spirit of turpentine. It is manufactured in large quantities, by distilling turpentine in an iron still, with a condensing apparatus, until the drops of oil begin to grow coloured.

One cwt. of turpentine yields from 12 to 20 pounds of oil; the slower it is distilled, the greater is its yield in oil.

Oil of turpentine is used principally to add to oil paints of light colours to cause them to dry quickly; it is also used in the composition of varnishes; and to take spots of grease and paint out of clothes, which it performs by dissolving them, and then being volatilized itself by the application of a hot iron, it carries the grease along with it.

When turpentine is dear the oil is distilled from frankincense, but it is very greasy, and far inferior to the real oil.

For medical purposes, the turpentine is either distilled with water, as other essential oils, or rectified with it: but it absorbs water in this process, and becomes useless to painters.

Camphire.

The rough camphire, brought from the East Indies, requires to be refined by sublimation, on account of the foulness that it acquires during the rude distillation of it, as practised by the country people of those parts, who only throw branches of the camphire laurel into water, boiling in a pot, and receive the sublimed camphire in another pot, stuffed with straw ropes, and placed with its mouth downwards on the boiler: the camphire adheres, in small grains, to the straw ropes, from which it is afterwards shaken.

Each cwt. of rough camphire is mixed with 2 pounds of quicklime, in powder, and the whole charged into flattened bolt heads, which are placed in a sand heat, and the sublimation performed in a very gentle heat. This operation requires considerable skill to form a solid nearly transparent cake of camphire, that being the marketable quality.

The bolt heads are placed on the sand, and that gradually raised round them, so that by the time the camphire is melted the sand reaches to the surface of the melted camphire: the whole bulk of the bolt head is then covered with the hot sand to melt the camphire that has sublimed during the melting, and cause it to run down. The upper part of the bolt head is then gradually uncovered as the camphire sublimes. When the sublimation is finished the bolt head is cooled and broke to extract the cake of refined camphire; the sublimation of 2lbs. $\frac{1}{2}$ of camphire lasts about seven or eight hours.

As a skilful operator has more command over a naked fire than a sand bath, and this operation requires great attention to the heat, some chemists prefer coating the lower half of the bolt heads with a clay lute, and hanging them in a pot furnace, with a separate fire to each; the management of the sand with which the upper part of the bolt head is covered is the same as in the former mode.

Another method has been proposed to prevent the expense of breaking the bolt heads, which is, to distil the camphire in a retort, or an iron pot with a stone ware head, with a quick fire that it may not settle in the arch or neck of the distilling vessels, but be forced over in a liquid form into the receiver, which is a large globe of tinned copper. The lower half of this globe is a separate piece luted to the upper half; and when the distillation is finished and the vessels cooled, this lower hemisphere is separated, and held over a fire to melt the surface of the camphire next it, and being then turned over the cake of camphire falls out.

Camphire is principally used in medicine, and in the composition of fireworks; its volatility prevents its being used in varnishes, where its whiteness would be very advantageous.

Ether.

Ether, as is learned from Raymund Lully and the Hon. Mr. Boyle, was originally prepared by digesting three parts of good spirituous wine with one part of oil of vitriol for six weeks, and then distilling the mixture with a gentle heat: the ether thus obtained was then called *philosophical spirit of wine*.

At present ether is made from spirit of wine, and without previous digestion. Highly rectified spirit of wine being put into a glass retort, there is added, by degrees, an equal weight of oil of vitriol; the retort being shaken on each addition of the acid and placed on warm sand, so that whatever is condensed in the neck may run back into the bowl of the retort, the mouth being stopped with a cork. When all the acid is introduced, the retort is placed in the proper position for distillation in a pot of warm sand, and there is luted to it with all expedition a stoppered and quilled receiver, a receiving bottle to the quill, and a bent pipe to the stopper hole, to convey the vapours into another bottle: all prepared beforehand.

The mixture in the retort is brought as quickly as possible to boil gently, and kept at that heat until white vapours begin to appear, which generally happens when a quantity of ether has been distilled which is equal to two-thirds of the spirit of wine. The receiving bottles are then unluted, removed, instantly stopped with corks prepared for that purpose, and fresh bottles applied to the receiver. The distillation is then continued with an increased heat until the mixture grows black and begins to rise in froth, when the fire is withdrawn and the fire room filled with cold wet bricks.

The liquor distilled in the first part of the operation has an ounce of fresh slaked lime added to each pound of fluid, and the whole is shaken together, and being decanted is mixed with an equal quantity of water, shaken together, again decanted, muriate of lime, or chloride of calcium, added to absorb the water, and the whole distilled in a smaller apparatus similar to that used at first.

Hellot observes in his papers on ether, in the Mem. Acad. Sciences, that in endeavouring to prevent the formation of the ethereal oil of wine, or as it was then called, the sweet spirit of vitriol, he found that 6 ounces of well dried and powdered potters' clay being put into a retort, 16 ounces of spirit of wine poured in also, and then 8 ounces of oil of vitriol, and the whole digested for three or four days, the mixture acquired no sensible colour. On submitting this mixture to distillation without taking any great care as to the heat, but keeping the liquor

boiling until the whole was brought to dryness, it yielded only a few drops of undecomposed spirit of wine, and the whole remaining distilled liquor was the vinous acid spirit containing ether, without any production of oil of wine, sulphurous acid liquor, or black scum.

The great volatility of ether requires extraordinary precautions to preserve it; it is best kept in a phial closed with a fresh sound cork every time it is opened and tied down. If it is to be kept for any time, a little quicksilver is to be put into the phial, which after being corked, is kept with the mouth downwards in a jar of water.

The extreme ease with which ether and its vapour catches fire is also another source of trouble to the chemist, and almost precludes its being poured out in a room or laboratory where there is either fire or candle. Should a stream of fired ether run along a floor, water is useless in extinguishing it, as it rises to the surface, and takes fire again; wet sand or ashes is the only remedy, and hence, one of these should always be in readiness in distilling ether.

Ether is used in medicine; and in gilding steel, as when poured upon solution of gold in aqua regia, it takes up the gold from the acid: it is also used in some varnishes, but its great price is against its employment.

Ethereal Oil of Wine.

This is a secondary product, obtained by continuing the distillation after the acid vinous spirit containing the ether has come over.

In the process for ether, as already given, the ethereal oil comes over along with a sulphurous acid liquor in the second set of receiving bottles, mostly of a yellow colour, some of it floating on the acid liquor, and some sunk at the bottom.

Some chemists, instead of increasing the heat when the second set of receiving bottles are adapted to the receiver, diminish the heat, and when the rising of the black froth takes place they remove the retort from the fire, and add to the liquor left in it some water to separate the oil, which they afterwards shake along with lime water to remove any acid it might retain.

Mr. Phillips denies the existence of ethereal oil of wine; what he prepared was ether mixed with about five-thirty-second parts of sulphurous acid; what he bought at different shops in London was yellow ether without any sulphurous acid.

Hellot found that the sensible qualities of ethereal oil of wine differed according to the proportion of oil of vitriol added to the spirit of wine in the first admixture. When one part of oil of vitriol is added to three, four, five, or six parts of spirit of wine, the ethereal oil was white, and always floated upon the acid liquor; with two parts of spirit the oil was yellow, and most commonly under the acid liquor; with equal parts of spirit of wine and oil of vitriol the ethereal oil was greenish, and constantly under the acid.

Ethereal oil of wine is only used in medicine, and but seldom.

Coal Nafta.

This is obtained in distilling coal tar, the distillation being begun with a very gentle heat, and the produce removed as soon as the oil comes over of a reddish colour.

If a still finer article is desired, the white nafta is withdrawn as soon as the oil comes over of a yellowish tint, and the yellow nafta is then collected separately.

Coal nafta is used in preparing varnishes; and has also been used in lamps, in which last use its aptitude to take fire, which is nearly equal to that of ether, requires peculiar precautions to be taken.

Oil-gas Oil.

This is deposited in the vessels in which oil gas is compressed to one-thirtieth of its bulk, to be afterwards transferred to portable gas lamps.

One thousand cubic feet of oil gas by compression, produce nearly a gallon of this oil.

It is used to dissolve Indian rubber, and is the best solvent yet known for that purpose. As it is so far more volatile than oil of turpentine, it would answer for making varnishes which are required to dry very quick.

Pyroligneous Ether,

Is obtained copiously in the distillation of wood; it burns with a peculiar smell, but is an excellent fuel for lamps, and much cheaper than spirit of wine.

DISTILLED OILS.

These differ from the ethereal oils by being less volatile, and thus by requiring a greater heat to raise them, they have acquired a dark colour, and a burnt or smoky odour, whence they have been called empyreumatic oils.

Tar.

This is obtained as a secondary product in making charcoal of resinous woods; namely, of the pine and fir trees.

The general process is to mark out a circular tar hearth in the forest, of about 30 feet in diameter, which is paved with a slope towards its centre, or at least formed of a thick bed of well-rammed clay. From near the centre a trough, or covered gutter is formed, which is frequently only a tree split, hollowed, and then joined together with clay, with which it is also coated to defend it from the fire. This trough ends in a cistern sunk in the ground to receive the tar as it flows from the trough.

A pole 15 or 18 feet long being stuck upright in the centre of the hearth, the billets, or fagots of resinous wood are piled round it in a bed of about 20 feet in diameter. Upon this a

bed of less diameter is made, and so on decreasing gradually to form a conical pile; which is covered with fresh cut turfs, leaving a few openings round the pile on a level with the ground. The whole being left for a day or two to settle, the pole in the middle is withdrawn and the pile lighted at the bottom holes. When the pile is well lighted the holes are stopped, and should the fire appear by any cracks in the covering, fresh turfs are laid to the place. The third day the end of the gutter next the cistern is opened, which had hitherto been stopped, and the tar already made, permitted to run out. This opening is then closed again, and only opened two or three times a day during the remainder of the process.

The tar thus obtained generally requires to be heated in large iron pots, to drive away the water and pyroligneous acid that runs out along with it, and cannot be separated by ladling, and also to allow the sand and other impurities which the tar contracts in this rude process to settle, and be thus separated.

In Sweden and Norway, where the Scotch fir, or *pinus sylvestris*, is a regular crop, tar furnaces are built of brick work, perfectly similar to these piles, and hence their tar being clean, is of a superior value in the market.

In North Carolina, from whence the greater part of American tar is brought, the pitch pine, *pinus palustris*, is used; and those trees which have fallen down in the woods, and the sap wood rotted off, are preferred, under the name of light wood, so called because it takes fire very readily. A pile of this pitch pine, 20 feet in diameter and 14 feet high, is computed to produce 200 barrels of tar.

Green Tar.

This is made in the same manner as common tar, from the wood of those trees which have done yielding turpentine by incision.

All the French, or Bordeaux tar, is made in this manner from the sea-pine, *pinus maritima*, and much of the American.

Tar is used as a cheap varnish for wood work; as also as a raw material to make pitch.

Pyroligneous Tar.

This is a secondary product collected in distilling wood which is not of a resinous nature, to obtain pyroligneous acid, or charcoal, for making gunpowder, as described in p. 289.

It may be used for the same purposes as tar: with which, however, it will not unite.

Coal Tar.

This has been prepared ever since 1740 in brick furnaces, similar to those used for preparing the common tar. These furnaces yielded a barrel of tar from 2 to 4 tons $\frac{1}{4}$ of the small coal, which is scarcely saleable and usually wasted.

Since the use of coal gas for illumination, this tar has been a secondary product, as described in the article on coal gas. It may be used for the same purposes as common tar; but as some prejudices exist against its use, it is mostly employed for illumination.

Oil of Bones,

Obtained as a secondary product in distilling bones, for the production of hartshorn or bone spirit, and ivory black.

On account of its fetid smell, it is only burnt for lamp-black: and in Galicia for miners' lamps, as it gives a very brilliant light, and will burn in air from 100 parts of which only 18 parts of oxygen can be obtained.

Now that flock paper is out of fashion for rooms, the French add chopped woollen cloth, and refuse wool to the bones.

Oil of Birch Bark.

The Russians obtain this oil by filling a large earthen pot, with the thin whitish paper-like external bark of the birch tree, carefully separated from the coarse bark, closing the mouth of this pot with a wooden bung, pierced with several holes; and then turning it over and luting it with clay to the mouth of another of the same size. A hole being dug in the ground, the empty pot is buried in it, and a fire is lighted round and over the pot containing the bark, which is continued for some hours, according to the size of the pot. When the apparatus is cooled and unluted, the lower pot contains the brown oil, mixed with pyroligneous tar, and swimming on an acid liquid.

In some places iron pots are used for this purpose, and the bark is hindered from falling into the lower pot by a plate of iron, pierced with holes; 100 pounds of bark yield about 60 of oil.

The waste of fuel in this process may be avoided by placing the pots in the side chamber of a reverberatory furnace, filling the chamber a little above the joining of the pots with sand, and then proceeding to distillation.

This oil is used in Russia for currying leather, to which it gives a peculiar odour, and a power of resisting moisture, far beyond any other dressing. Its use seems to have arisen from observing that the thin paper-like leaves of birch bark, remained after the coarser part of the bark, and the timber of fallen trees had rotted. The oil appears to owe this quality to a resin, which, by this mode of distilling per descensum, is allowed to escape in a great measure from the action of the fire, and drop into the lower pot.

Other barks, as those of the oak, willow, poplar, alder, as also poplar buds, rue, and savine, have been tried, but the produce from them was only a stinking oil. Birch wood yields only a stinking oil totally unlike the oil of the external bark. Cork yielded an oil approaching in some degree to that of birch bark.

Oil of Benzoin.

This oil is distilled from the residuum left in making flowers of benzoin by sublimation. The distillation is effected in a retort, or in an iron pot with a stone ware head.

It is used for currying leather in imitation of the Russian leather.

FIXT OILS AND ROSINS.

The distinctive marks of these oils is, that they cannot be distilled without becoming an entirely different thing.

A great proportion of the fixt oils in use are not obtained by chemical means, but by mechanical pressure: the construction of oil mills for this purpose is excellently shown in Nicholson's Operative Mechanic. To this class belong the various qualities of olive and rape oils, as also nut oil, linseed oil, and many others.

Pitch.

Two methods are in general use for making pitch; namely, either simply boiling the tar in large iron pots, or setting it on fire and letting it burn, until by dipping a stick into it the pitch appears to have acquired the proper consistence.

Two barrels of the best tar, or 2 barrels $\frac{1}{2}$ of green tar are computed to make one barrel of pitch.

Pitch is used as a coarse varnish for ships' bottoms, also to close the joints of carpenters' and coopers' works, to enable them to retain water.

Brown Rosin.

This is the residuum left in the still after turpentine has been distilled without water for its oil; and which is run or ladled out of the still into casks cut in half for sale.

Its colour is more or less dark, sometimes approaching nearly to black, according to the degree that the distillation has been pushed.

It is used as the base of many common varnishes and cements; also to sprinkle on the surface of metals that are to be joined with another metal, in order to promote their union. It is also made with tallow into a soap.

When melted with a little vinegar to render it clammy, it is used by violin players to rub their bows.

Yellow Rosin.

This is made by ladling out the brown rosin from the still into

a vessel of hot water; a violent effervescence takes place, and the rosin absorbs one-eighth of its weight of water.

It is used for the same purposes as brown rosin, but is less hard, and therefore less adapted for cement; its light colour, however, is sometimes advantageous.

Spirit Varnishes.

Almost every workman that uses varnish has his own receipt for making it. These receipts are mostly remarkable for the number of ingredients, some of which are of scarcely any use, and others absolutely hurtful to the wished for effect.

Brown rosin, gum sandarac, mastic, shell lac, seed lac, dissolved in strong spirit of wine, generally form the basis; Venice or common turpentine is added to prevent the varnish from cracking as it dries; camphire, anime, benzoin, alemi, are occasionally introduced; also gamboge, turmeric, dragons' blood, saffron, and lamp black, as colouring ingredients.

The common varnish is made by dissolving 4 ounces of sandarac, and 6 ounces of Venice turpentine, in a pint of spirit of wine.

A harder varnish is made by dissolving 2 ounces of mastic, 1 ounce $\frac{1}{2}$ of sandarac, and 1 ounce $\frac{1}{2}$ of Venice turpentine in a pint of spirit of wine.

A very hard varnish, much used of late by the name of *French polish for furniture*, is made by dissolving 3 ounces of shell lac, with 1 ounce each of mastic and shell lac in 2 pints $\frac{1}{2}$ of spirit of wine in a gentle heat, making up the loss by evaporation by adding more spirit at the end of the process.

The plain solution of either mastic or sandarac in the proportion of about three ounces to a pint of spirit of wine makes very good varnish.

Yellow varnishes are used by the name of *lacquers* to give a golden colour to metals, wood, or leather: the following is, perhaps, that most used: colour a pint of spirit of wine with three-quarters of an ounce of turmeric, and fifteen grains of hay saffron; filter and dissolve in it two ounces each sandarac and elemi, one ounce each dragons' blood and seed lac, and three-quarters of an ounce of gamboge.

Black varnish is made for sale by dissolving half a pound of sandarac, and a quarter of a pound of yellow rosin, in half a gallon of spirit of wine, and then adding two ounces of lamp black to colour it. But workmen generally make it by dissolving black sealing wax in spirit of wine.

The making of varnish from copal is a matter of difficulty, as copal is not soluble itself in its raw state in the spirit. One method is to add camphire to a pint of highly rectified spirit of

wine until it ceases to be dissolved, and to pour this charged spirit upon four ounces of copal, keeping up such a heat that the bubbles may be counted. When cold pour off the varnish, and if all the copal be not dissolved, add more spirit impregnated with camphire. Another method is to heat the copal and let it drop as it melts into water; a kind of oil separates from it, and it becomes soluble in ardent spirit, and still more so if the melting is repeated.

Oil Varnishes.

In these varnishes, as in spirit varnishes, almost every operator has his own receipts. So that it is only the general outlines of their composition that can be given.

Drying oil, or boiled oil, is one of the most common varnishes, and is used to mix with colours, partly as a vehicle, and partly to cause them to dry quickly. Linseed, or nut oil, is boiled with a very small proportion of dried white lead, litharge, dry saccharum saturni, or white vitriol, generally an ounce either of each article, or a proportionate quantity of several to the heat of oil. Sometimes the oils are merely left to stand upon litharge for a long time.

Oil varnishes for covering pictures are not much used, as they are not easily removed. They are mostly composed of gum mastic, various proportions of copal varnish, Canada balsam, and thinned with oil of turpentine.

The varnish used for bright armour and weapons, by our ancestors, was, 3 lbs. of brown rosin, 2 lbs. of turpentine, dissolved in 10 pints of boiled linseed oil.

The engravers' varnish for covering copper plates, and preventing the acid used in etching from corroding the places wished to be left blank, varies much in its composition. The hard varnish used with Callot's aqua fortis is merely mastic dissolved by boiling in an equal weight of drying linseed oil. Le Boffe's soft varnish, which is that generally used in England, is made by heating 2 oz. of white wax, and adding to it, by degrees, first, 1 oz. of mastic in fine powder, and then 1 oz. of asphaltum, keeping it on the fire until all is completely dissolved. Mr. Lowry used 4 oz. of asphaltum, 2 oz. of Burgundy pitch, and 2 oz. of white wax, melted together. The varnish called *the soft ground* is prepared by adding some veal suet to the soft varnish already described.

The French artists use gum benzoin instead of asphaltum, making their soft varnish of eight ounces of linseed oil, in which is dissolved one ounce of gum benzoin and white wax, and keep it on the fire till one-third is boiled away. For their hard varnish they add more white wax, so as to enable it to be made into a solid ball.

The superior clearness of copal to either shell lac or amber, gives it an advantage in varnishes and japan work; but the difficulty of dissolving it, either in oils or spirits, is very great. By grinding it with camphire, or by first melting it and letting it drop into water, it becomes more soluble.

The Japanners' copal varnish is made by melting 4 lbs. of copal in a glass matras, until the vapour condensed upon any cold substance, drops quietly to the bottom; then adding first a pint of boiling linseed oil, and afterwards about its own weight of oil of turpentine.

Le Blond added 1 oz. of copal to 4 lbs. of balsam of capivi, exposing it to the sun until dissolved; then added another ounce, and so on until he got in a pound of copal; he then added Scio turpentine as he thought necessary, and used this for varnishing prints.

Sheldrake prepared his copal varnish for varnishing pictures, by mixing 1 pint of oil of turpentine, with 2 oz. of aqua ammonia, and dissolving 2 oz. of copal in this mixed liquor, by a heat regulated so that the bubbles as they rise may be counted. For mixing up with painters' colours, he boils 2 oz. of ceruss, with a pint of nut or poppy oil; and when the ceruss is dissolved, adds a pint of his copal varnish, previously warmed, and stirs it until the oil of turpentine is evaporated. This gives the colours more brightness than common drying oil, but less than common varnish. It loses its drying quality in time, therefore only so much as is sufficient for a month or six weeks' consumption should be made at once.

Boiled Oil.

As the oil used in oil painting is required to dry very fast, the oil of linseed and walnuts have their own natural drying qualities augmented by being boiled slightly with white lead, red lead, sugar of lead, litharge, German, or white vitriol; using about four ounces of any of them to the gallon of oil. The pure sulphate of zinc made in England has not the same drying quality as the common white vitriol imported from Germany.

The oil for painting on velvet is also made drying by boiling. Very clear linseed oil one pint, add sal ammoniac and sal prunelle, of each twenty grains, boil for two hours, then put in a piece of bread soaked in oil of vitriol, and three large onions cut into pieces, and continue the boiling for another hour, strain through a coarse cloth.

Fired Oil, or Printers' Varnish.

If the colouring material of printers' ink were mixed up with raw linseed oil or nut oil, it would not give so clear an impression, the small letters would soon fill up, the impression of the large letters would be surrounded by a greasy border, and as the ink would be long in drying, the impression would be extremely liable to accidental smears, and the book could not be bound for months after it was printed, without marking the opposite page. All these inconveniences are prevented by heating the oil in an iron pot, and setting it on fire, until on dipping a wooden knife into it the operator judges, by the ropiness that is acquired by the oil, that the varnish, as it is now called, is properly made. The pot is then covered to extinguish the flame, and the fire under it withdrawn.

Japan Work.

The natives of Japan and China have a decided advantage in manufacturing fine japan work in regard to their material. They use the turpentine obtained by incision from the terminalia ver-

lax, which becomes a hard black rosin by exposure to the air. To hasten this effect it is put into very shallow bowls, and continually stirred with an iron rod during twenty-four hours, so as to expose every part to the action of the air. This makes it thicker than before, and of a fine black colour.

When this lac is laid on the work and dried, it is polished, and the polished surface is ornamented by gilding or painting, which is secured by an external coat of varnish, made of oil and turpentine, boiled to a proper consistence. For coarse work lamp black is added.

The japanning of Europeans is differently performed; but the work bears a near resemblance to that of the Japanese when finished: it is applied to wood, papier-maché, leather, and iron, or tinned iron. When the articles are of that nature that they will not bear heating in a stove to dry and harden the japan, they must be done with lac, reduced to a fluid state, by dissolving it in some essential oil, and this varnish being spread on the work, the oil will evaporate, and leave a hard superficial coat of japan. The varnish may be mixed with the requisite colours, or the colours may be painted upon the surface of the varnish between the successive coats which are applied; and in the latter case, admit of painting according to a design.

For such goods as will admit of sufficient heat in a stove, a more economical method is pursued, the principal coats of japan being made of boiled linseed oil with proper colouring matters. These are dried and hardened in the stove, and the painting or gilding is laid on; a thin lac varnish is lastly applied to give the external surface.

Japanning with Lac. This is principally used for ornamenting wood, leather, and paper, but the latter can be japanned by heat like the metals.

Varnishes which are to form the grounds or surfaces on which the painting or gilding is to be laid, are thus produced.—Dissolve two ounces of coarse seed lac, and two ounces of rosin, in one pint of rectified spirit of wine. This varnish must be laid on in a warm place; and the work will be better done if the substance to be japanned can be warmed also. Two or three coats of this coarse varnish are applied, preparatory to laying the grounds.

For a *white ground*. Grind flake white with one-sixth of its weight of starch, temper it with mastic varnish, prepared by dissolving mastic in spirits of turpentine, by a gentle heat in a warm bath; or the colour may be compounded with gum anime, reduced to powder, and ground first with turpentine, and then ground with the colour, adding as much of the mastic varnish as is necessary to make it work with the pencil.

When this white japan is laid on, the external varnish which is applied upon it, after the painting or ornaments are finished, must be of the most transparent nature, that it may not injure the whiteness of the colour. Take two ounces of chosen lac and three ounces of gum anime, reduce them to a gross powder, and dissolve them in two pints of spirit of wine; five or six coats of this varnish must be laid on over the white colour. The seed lac will give a slight tinge to the colour, but the hardest varnish cannot be made without it. When hardness is not so essential, a less proportion of seed lac may be used; and to take away the brittleness of the gum anime, a small quantity of crude turpentine may be added. Another varnish, either for mixing up with the white colours or for covering them when laid on, is made of gum anime dissolved in old nut or poppy oil, by gently heating the oil and putting into it as much of the gum as it will take up. This varnish must be diluted with oil of turpentine for use; it will not bear polishing, and therefore must be applied very carefully that it may lay smooth.

For *blue japan grounds*, use a bright Prussian blue, or smalt, or verditer glazed over by Prussian blue; the colours are best mixed with shell lac varnish, and brought to a polishing state by five or six coats of seed lac varnish. If the blue ground is bright, and the shell lac varnish is laid on, it will give a green hue, owing to its own yellow colour.

For *red japan grounds* vermilion may be used to produce a scarlet ground, but it has a glaring effect when used alone: this is corrected by glazing it over with carmine or fine lake, or even with rose pink. For a very bright crimson Indian lake may be used; the lake may be dissolved in the spirit of which the varnish is composed, and a coat of this being laid on, the shell lac varnish may be used to produce the external surface, as it will very well transmit the tinge of the Indian lake.

For *yellow japan grounds*, bright yellow, king's yellow or turpeth mineral should be employed, either alone or mixed with fine Dutch pink. The effect may be heightened by dissolving powdered turmeric root in the alcohol, which is used for making the external varnish. Dutch pink alone, if of the best quality, will make a good yellow ground.

For *green japan grounds*, king's yellow, or turpeth mineral with bright Prussian blue, may be mixed to make a green. A common kind may be made of verdigris, mixed with either of the above yellows, or with Dutch pink. For a very bright green, distilled verdigris should be employed; and to heighten the effect, the colour should be laid on a ground of leaf gold, which renders it very brilliant.

For *orange japan grounds*, mix vermilion or red lead with

king's yellow or Dutch pink, or orange lake used alone is a fine colour.

For *purple japan grounds*, a mixture of lake and Prussian blue may be used, or vermillion or Prussian for a coarser purple.

For a *black japan ground*. Ivory black and lamp black are the proper materials. They should be laid on with shell lac varnish, but the external varnish may be of seed lac, as the tinge of it can do no injury.

For *gold grounds*. Gold leaf may be laid on over the whole surface. Or the imitative gold or silver powder may be used with size.

When the desired ground is obtained, the ornamental painting is next performed. The colours for painting are mixed up with varnish of shell or seed lac, dissolved in spirit of wine, or otherwise, by mastic varnish, dissolved in oil of turpentine; to which gum anime may be added, as before directed, for mixing up the colours of the white ground, and which applies to all the other grounds. The pencils must be moistened either with the spirit of wine or oil of turpentine, so as to make the colours work. In some very nice works, the colours may be tempered in oil, for the more free use of the pencil, and to obtain greater despatch. The oil should, previously, have one-fourth part of its weight of gum anime dissolved in it, or gum sandarac or mastic. When this oil is used, it should be diluted with spirit of turpentine, that the colours may lie more even and thin.

When the painting is to be on a ground of gold, water colours may be used for the ornamental painting. They are prepared with isinglass size, corrected with honey or sugar candy.

External Varnish. The hardest varnish is made of seed lac, but has a yellow tinge. To make this, wash the seed lac in water, dry it, powder it coarsely, then put three ounces of it into a bottle, with a pint of rectified spirit of wine, and keep it in a warm place, until as much of the lac is dissolved as can be; the varnish is then to be poured off. This varnish must be laid on in a dry warm place, and the work previously made perfectly dry.

When the outer varnish has been as often repeated as is necessary, the work is polished with fine powdered pumice stone, or rotten stone; and when a good surface is thus obtained, it is finished by rubbing it with the hand alone, or with butter or oil.

About the middle of the last century almost all elegant furniture was japanned by these means; but it is now disused, except for coaches, and for some small articles. The japanning of such articles as will bear the heat of a stove, to harden the varnish, is now brought to a very high perfection, and is very cheap, compared with the lac japan.

Japanning of tin and paper wares by the stove, is distinguished into two kinds; *clear work*, in which the japan is required to be transparent; and *black japan*, which is opaque.

The varnish for *clear work* is composed of raw linseed oil, umber, and a little amber, with a small portion of white rosin, boiled for several hours in a cast-iron pot, which is set in brick work, over a furnace, and the mouth of the pot surrounded by a funnel or chimney of brick work, with only one opening to obtain access to it; and this opening is provided with an iron door to shut close, in case the materials should take fire. The boiling is continued until by letting fall a drop on a piece of tin plate, it keeps in a circumscribed spot. This varnish is mixed up for working with spirit of turpentine, the varnish being a little warm.

The *black japan varnish* is made by the same process, but asphaltum is used instead of amber; and it is thinned for use with tar spirit, instead of spirit of turpentine; lamp black also is added to the varnish.

Either of these varnishes are to be laid upon the work by a soft hog's hair brush. The work is left for a few minutes to set, and it is then put into the drying stove for thirty or forty minutes; it may then be taken out, and suffered to cool previous to varnishing again. The proper time for the second application is, when the finger will not slide over the surface, at the same time that there is no actual sticking to the finger. After several coats have been applied, the work is left in the stove five or six hours, or all night, to harden or dry off the varnish.

If it is the clear varnish which is thus treated, this time will be sufficient; but it will grow darker in proportion as it is longer exposed to the heat, or as the heat is increased. For black work the heat is raised as high as possible, without melting the soldering, or charring the varnish; and this is continued three or four days. This process makes the hardest and most durable of all varnishes, and of a most brilliant jet black colour.

Mottled Japan, in imitation of Tortoiseshell. This is done by covering tin plate with one coat of varnish as above, mixed with Venetian red, and then it is coated with black varnish. The fingers are drawn over the varnished surface in a waving direction, to distribute the varnish unequally, and thus cause the red colour to be seen through in spots or clouds, imitating tortoiseshell. Otherwise the tin is painted in spots, with vermilion mixed in shell lac varnish; and this is coated with the clear varnish, which is afterwards stoved till it becomes deeply coloured, and is rather opaque, so that it shows the ver-

million spots and the surface of the tin beneath in an imperfect manner, and much resembles the clouds of tortoiseshell. Some simple articles in wood may be treated in this way; for instance, walking canes are most beautifully ornamented at Birmingham.

These processes of japanning by heat are to be found in some receipts by Kunckel, but do not appear to have been practised till the Birmingham manufacture was begun.

When ornamental painting or gilding is required, it is done upon a clear japan ground, when the same is set. A layer of gold size being spread over the surface, the leaf gold or gold powder is applied, and also the required painting. Stencils are sometimes used to lay the gold powder in particular patterns. A variety of different coloured metallic bronze powders are used in the Birmingham ware; and for the smaller parts, they lay them on with stump brushes.

Transparent Japan, or Pont-y-pool Japan. The articles japanned in this way are prepared by a good ground of black varnish, made very smooth; a layer of gold size is then laid on, and the whole surface is covered with silver powder. Upon this is laid a coat of thin varnish, mixed with the desired colour. When this is dry, it is sized over, and painted or ornamented with gilding in silver leaf or powder. The whole is coated with an external varnish of a gold colour, which changes the colour of the silver leaf to that of gold.

Crystallized tin plate, or *moirée*, covered with a fine transparent varnish, affords a beautiful article.

The stoves for japanning are built of brick or stone, generally three stories high, with three stoves upon each floor. The fire is at the bottom, and is covered over with a strong iron plate. The flues are carried up at the sides and ends of the stoves, and are made to afford three different degrees of heat; for drying off the clear varnish, or for darkening it, or for darkening the black varnish.

White Wax.

This is obtained by bleaching bees' wax by exposure to the sun and rain during the heat of summer.

Bees' wax collected in different districts varies much in the ease with which it may be bleached, and some cakes retain their yellow colour with such obstinacy as to be totally unfit for the purpose of making white wax.

The wax is therefore assayed by scraping off a little from the top and bottom of each cake, putting the shavings into a box divided into partitions which are numbered, and a correspondent number marked on the cake. The box is exposed to

the sun for some time, and a memorandum is kept of the time required for bleaching the shavings of each cake. When the bleaching process ceases, the cakes of wax are sorted into four qualities, namely 1st, 2nd, 3rd, white, and fourthly, yellowish or gray white, and unbleachable wax. The cakes of the last qualities are mixed with those that have been adulterated by the farmer with tallow or rosin, and sold for rubbing furniture or for giving toughness to the tar used for tarring ropes.

The cakes of the three first qualities are melted each sort by itself, in a tinned copper caldron having a pipe and cock at about one-third its height from the bottom. Water is first poured into the caldron, but not so much as to reach the discharge cock. The wax is then added, being first cut into pieces, and a gentle heat applied. When the wax is melted, four ounces of cream of tartar are added to each cwt. of wax, the whole well stirred together, and then allowed to settle, after which the discharge cock is opened and the wax run out into a wooden cistern placed so as to be kept warm by the fire. Here the wax is allowed to settle again, and then to flow out, while scarcely liquid, through a cock, upon a cylinder of wood turning in a trough of cold water, by which it is formed into thin ribands.

These ribands are exposed on hurdles to the sun and rain, and when no longer altered, the wax is remelted and formed again into ribands, and thus successively until the bleaching is completed. The ribands of bleached wax are then collected together in fine weather, remelted and strained through a sieve into moulds, either for cake or block white wax. If the wax was taken off the hurdles in rainy or moist weather, it would acquire a grayish tinge on being melted.

Many attempts have been made to bleach wax with oxymuriatic acid, but although the colour is changed, the wax becomes brittle, losing entirely its ductility, so that the manufacture by this agent has been obliged to be given up. The bad effects of the oxymuriatic acid are in other cases guarded against by the use of alkalies, but these cannot be employed in respect to wax, as they act themselves so much upon it.

Purified Rape Oil.

To one hundred gallons of rape oil add two gallons of oil of vitriol, mix and agitate them together. Upon this the oil presently changes colour, becomes thick and assumes a black greenish appearance. After three quarters of an hour it is full of flakes; at which time cease to agitate, but add 200 gallons of water to carry off the sulphuric acid, which, if suf-

ferred to remain too long, would act too strongly upon the oil, and carbonize it. It is necessary to heat this mixture during at least half an hour, in order to bring the particles of oil, of acid, and of water, into contact with each other; after which it must be left to settle. After about a week or ten days' rest, the oil swims above the water, and the water above a blackish substance precipitated from the oil by the sulphuric acid, which substance is the colouring matter of the oil, and prevents it from burning well. Even after this period of rest, the oil that forms the upper station is far from being clear, and it would perhaps require twenty days to render it transparent by rest alone; but by filtering the oil, it immediately becomes perfectly clear and pellucid. By this process an oil is obtained infinitely more free from colour, taste and smell, than that commonly employed, which burns with the greatest ease, and in all respects worthy to be compared with the purest oils of commerce; add to which, that the loss in quantity is very inconsiderable.

If it be desired to obtain a still whiter oil, it may be subjected to a second process; but then one gallon of oil of vitriol will suffice for 100 gallons of oil. In purified oil this acid does not cause a blackish sediment, but, on the contrary, of a grayish white, and in no great quantity. This sediment separates less easily from the oil than the preceding.

This oil gives a brilliant light, but inferior to that of the oil of sesamum, *huile de cameline*, which is mostly burned in the street lamps of Paris.

Mr. Field's apparatus, fig. 359, and 360, is well adapted for filtering this and other oils, as it allows nearly the whole pressure of the atmosphere to force the oil through the filters.

Ceromimene.

Braconnot and Simonin have endeavoured to use the stearine, or solid part of animal fats, as a substitute for wax.

The suet, or fat of any animal is diluted with oil of turpentine, and pressed in boxes lined with felt, the sides and bottoms of which are pierced with small holes; the stearine that remains in the box is then boiled a long time in water, to get rid of the odour of the turpentine. It is then melted, and fresh heated bone black is added; after some hours' fusion it is filtered while boiling hot.

In this state the ceromimene, or prepared stearine, is brilliant, white, and semi-transparent, but extremely brittle; to give it sufficient tenacity for moulding, a fifth part of bees' wax is melted along with it; or it may be hardened by a slight exposure to oxymuriatic, or muriatic acid.

The oil and elaine expressed from the fat are separated by distilling off the oil, and the elaine being purified by bone black may be used for making soap; but the smell is rather disagreeable.

Sealing Wax,

Is a kind of cement made by melting lac, or rosin, with turpentine and colouring materials.

The Indian sealing wax is made by melting stick lac with a very small quantity of Scio turpentine and Chinese vermilion.

The best Dutch sealing wax is made by melting four pounds of light coloured shell lac, adding first a pound of Venice turpentine, and then three pounds of Chinese vermilion, stirring all well together, and when it is nearly set, a quantity sufficient for six sticks is taken and weighed.

The sticks are made on a marble slab fixed in a frame, with a chafing dish placed under the slab to keep it properly heated. The sealing wax is first rolled upon this slab with the hands until it is reduced to a roll nearly the length of six sticks, and then brought to the exact length by being rolled with a square piece of hard wood with a handle.

The sticks are then transferred to another workman, who rolls the stick upon a cold marble slab, with a marble roller, until it is quite cold, and then polishes it by holding the stick between two charcoal fires, placed at a small distance opposite each other, until the surface is become smooth by beginning to melt, keeping the stick constantly turning. As the long stick grows hard the length of each of the six future small sticks are deeply indented in their proper places.

A third workman breaks the long stick into small sticks, and finishes them by holding the ends to the flame of a lamp, and impressing on one end the manufacturer's mark.

Oval, channelled, or ornamented sealing wax is made by pouring the mass into steel moulds.

Golden sealing wax is made in a similar way, only substituting powdered yellow mica, or cat gold, for vermilion. The lac and turpentine, forming a brownish red transparent mass, which allows the scales of the mica to be seen, and forms a kind of *avanturine*.

Sealing wax is made of other colours by substituting the different metallic colours for vermilion; and it is sometimes even marbled, by working together different coloured wax just ready to set. The French even perfume it with essence of musk, or any kind of essence.

Sealing wax of inferior quality is made by substituting rosin in part or even entirely for the lac; red lead or bole for the

vermilion; and common turpentine for that of Venice. A false appearance is given to the surface by softening the sticks between the two fires, and rolling them in a box of powdered sealing wax of a better quality; the sticks are then again softened between the fires to melt this false coat and give the wax the last polish.

Black sealing wax is made from dark coloured shell lac melted with common turpentine, and coloured with lamp black.

Soft Wax.

This is made by melting 20 pounds of block white wax with five pounds of Venice turpentine; and then stirring in a sufficient quantity of vermilion or verdigris, in fine powder, to give it the desired colour. The wax is then poured out on a slab of marble or hard wood, moistened, and formed into large rolls.

Soft wax is used for official seals, as requiring only to be softened between the hands; it is also used as a cement.

Diachylon, or Simple Plaster,

Is made by putting five pounds of finely ground litharge into a copper pan, adding a gallon of ordinary olive oil and about two pints of water, heating and stirring them all together, until the litharge is dissolved in the oil. When the whole is nearly cold it is poured out, and formed into rolls upon a marble slab.

This operation requires care to prevent the heat from turning the plaster brown; if it is necessary to add more water to moderate the heat, the pan should be removed from the fire and let to cool a little before fresh boiling water is added.

Diachylon is used by the surgeons as the basis of many plasters, made by remelting it and adding various resinous substances.

Purified Fish Oil.

The finks, or Greenland blubber, produced from whales, is brought home, cut into small pieces, and packed in casks, and when it arrives in England it is in a putrid state.

It should be started into a large back or receiver, containing about twenty tons; from thence the fluid parts are suffered immediately to strain through a semicircular wire grating, in the side of the back, close to the bottom. The grating should be about four feet wide and two feet high, receding in a convex form into the back, and the wires sufficiently close to prevent the finks from passing through. The oil, as it drains through this grate is to be conducted, by means of a copper pipe, into another back containing about the same quantity. When this second back is full it should be left about two hours to settle, after which it must be conducted, by means of a sluice, into a copper, containing about fourteen tuns, heated by a fire in the usual way. The oil must then be kept stirring in the copper

until it has acquired heat equal to 225 deg. Fahrenheit, which will destroy the rancidity of the smell, and also strike down all the gross or mucilaginous matter to the bottom. As soon as the copper of oil has received the before mentioned degree of heat, the fire must be immediately drawn, and about half a tun of cold water pumped upon the surface of the oil. This assists in cooling the bottom of the copper, and prevents the gross and mucilaginous parts from adhering to the sides.

In this state the oil should remain cooling in the copper for the space of one hour, and should then be conducted into other backs or coolers, and when perfectly cold should be drawn off into casks. It will then be fine, and fit for immediate use.

Another method of sweetening, purifying, and refining Greenland whale and seal oil, is to filter the raw oil through bags, about forty-one inches long, with circular mouths, extended by a wooden hoop, about fifteen inches in diameter, fixed thereto. These bags are made of jean, lined with flannel; between which jean and flannel powdered charcoal is placed throughout, to a regular thickness of about half an inch, for the purpose of retaining the glutinous particles of the oil, and straining it from impurities; and the bags are quilted, to prevent the charcoal from becoming thicker in one part than another, and to keep the linings more compact. The oil runs from the filtering bags into a cistern, containing water at the bottom about the depth of five or six inches, in each 20 gallons of which is dissolved about an ounce of blue vitriol, for the purpose of drawing down the glutinous and offensive particles of the oil which have escaped through the charcoal, and thereby rendering it clean, and free from the unpleasant smell attendant upon the oil in the raw state.

The oil is suffered to run into the cistern until it stands to the depth of about two feet in the water, and there to remain for three or four days (according to the quality of the oil;) and is then drawn off, when it will be found to be considerably purified and refined; the oil, after having undergone this operation, may be rendered still more pure, by passing a second or third time through similar bags and cisterns. But the oil, after such second and third process, is drawn off into, and filtered through, additional bags made of jean, lined with flannel, enclosed in other bags made of jean doubled.

A third method of purifying fish oil, is to take one gallon of crude stinking oil, and mix with it a quarter of an ounce of lime slaked in the air, and half a pint of water. Stir them together; and when they have stood together some hours, add a pint of water and two ounces of pearl ashes, and place the mixture over a fire that will just keep it simmering, till the oil appears of a

light amber colour, and has lost all smell, except a hot greasy soap-like scent. Then add half a pint of water in which one ounce of salt has been dissolved, and having boiled it half an hour, pour the mixture into a proper vessel, and let it stand for some days, till the oil and water separate.

If this operation be repeated several times, diminishing each time the quantity of ingredients one-half, the oil may be brought to a very light colour, and rendered equally sweet with the common spermaceti oil. Oil, purified in this manner, is found to burn much better, and to answer better the purposes of the wool-len manufacture. If oil be wanted thicker and more unctuous, it may be rendered so by the addition of tallow or fat.

For some purposes it is sufficient to add a pint of lime water to each gallon of stinking oil, stirring them well together for the first day, then to let the mixture settle, and draw off the purified oil.

Neat's-foot Oil.

This rises to the surface of the water in which neat's-foot and tripe are boiled.

It is only used in England for greasing harness, as it keeps the leather moist longer than any other oil. In France and Scotland it is used in cookery, particularly for making fritters.

SOAPS.

Soap is a combination of an alkali with oil or fat; the only alkalies used in making the soaps used in the arts are soda and potasse. Soap made entirely of soda is rather too hard for comfortable use, and hence some potasse is generally added: those made with potasse alone are soft and pasty. Soaps also differ greatly according to the oil used.

The pans in which soap is usually made, are heated only at bottom, which is also generally covered with alkaline ley, so that the fire does not act immediately upon the soap. The French soap pans are a large flat plate of iron or copper with the edges turned up like a frying pan; and the sides are built up of brick or stone work. The English soap pans are large cast iron pots, merely set upon the fire-room, the sides being left naked.

White Castille Soap.

In manufacturing hard soap from olive oil the usual proportions are 600 pounds of oil, 500 pounds of barilla, and 100 pounds of quick lime. The lime is first slaked, screened, and mixed with the barilla, water is poured upon the alkali, and in

three or four hours runs off: this first ley, called *capital ley*, should show 18 or 25 deg. Baumé, or the spec. grav. of 1.143 to 1.21. Fresh water is again poured on the alkalies, and a second ley obtained, showing 10 to 15 deg. Baumé, or the spec. grav. 1.075 to 1.116. A third ley is then made, showing 4 to 8 deg. Baumé, or the spec. grav. 1.029 to 1.06. The fourth ley, which exhausts the barilla of every thing soluble in water, is used to form the first ley of the succeeding operation instead of plain water.

The oil is then poured into the boiler, along with a portion of the third ley, and the mixture made to boil; the remainder of the third ley is added by degrees, and when this is consumed the second ley is gradually added; the boiling liquor being frequently stirred during the whole time. The oil turns milky, and after it has been boiled some time it acquires a greater consistency.

When this takes place the capital ley is added by degrees, and then the oil grows still thicker, and begins to separate itself from the watery liquid. A quantity of salt is now added, which renders this separation still more complete, and the soap is seen perfectly formed in a kind of granulated paste; which, on withdrawing the fire and allowing the whole to cool, collects at top, swimming on the spent ley, which is to be drawn off, and is used to lixivate the next mixture of kelp and lime, and thus form a ley that is employed towards the end of a new boiling.

The fire being re-lighted, the remainder of the capital ley is added by degrees; and a small quantity of the soap taken out from time to time, dropped on a slate to cool, and examined. When the soap has been sufficiently boiled, and the ley on which it swims has a spec. grav. of 1.150 to 1.2, it will appear dry when rubbed between the fingers, and in the boiler have the appearance of a dark gray paste, which may be made into white or marbled soap. To make white soap, the fire is withdrawn and the soap suffered to stand for some hours; after which the liquor, collected below the soap, is drawn off. The boiler is now heated again merely to melt the soap, and a small quantity of weak ley added. The colouring matter, which is a combination of fat matter, alumine, and oxide of iron, not being soluble in the soap at this temperature, falls gradually to the bottom, leaving the soap perfectly white.

Whilst the soap is settling in the boiler, the moulds are arranged, and a small quantity of powdered lime is spread as even as possible on the bottom of each, that the soap may not adhere to it. The soap is then ladled out or drawn off into the moulds.

After two or three days in winter, or more in summer, the soap will be sufficiently solid to be taken out of the moulds, and

divided into cakes. It is then conveyed into the drying rooms, and it is not fit for sale until it no longer yields to the pressure of the fingers.

Not more than five pounds of soap ought to be made from three pounds of oil; that is to say, a thousand pounds of soap from six hundred pounds of oil; but some dishonest manufacturers make one pound of oil into three pounds of soap, and even more.

The soap manufacturers of Marseilles follow this process; but each of them pretends that he has a peculiar secret of his own, which he conceals with a great air of mystery.

Marbled Castille Soap.

Marbled Castille soap differs from the ordinary white soap only by the colouring substances which are left in it, or are added to it, in order to tinge it with blue and red streaks or spots.

When the boiling of the soap is finished, and the ley on which it swims is of the spec. grav. of 1.15 or 1.2, the soap is, as has been already mentioned, of a dark gray colour, and loaded with colouring matter. To disperse this colouring substance in veins, it is necessary to dilute the soap with a little water, and to let it cool gradually. If too much water were added, and it is cooled too slowly, all the colouring matter will fall to the bottom, and leave the soap white; if sufficient water be not added, and it is cooled quickly, it becomes granular, like moor stone.

If the quantity of colouring matter derived from the barilla is not sufficient to colour the aluminous soap, a little copperas water must be added. Whether this addition is necessary or not, there is added to the dark gray rough soap, the necessary quantity of weak ley to bring it to the desired point of moisture, after which it is run into the moulds as usual.

To produce the red colour, colcothar, or Spanish brown, is diluted and mixed with water. A workman placed over the boiler stirs the soap, whilst another pours into it the red colouring liquid; and in order that this may mix in a uniform manner, the workman who stirs it takes care to make no other motion with his instrument than drawing it from bottom to top. The soap ought to be of the consistence of a paste when the red colour is added to it, and immediately put into the moulds. The moulding is somewhat more difficult with the marbled soap than with the white, the latter being more fluid at the time when it is run into the moulds.

Three pounds of olive oil yield five pounds of white soap; but the same quantity of oil affords only about four pounds and a quarter of marbled soap. This is the reason why the latter kind is more solid than the former; and for the same reason also

laundresses prefer the marbled soap, there being a greater quantity of effective soap in a given weight of the marbled kind.

This soap is preferred for exportation into hot countries on account of its hardness. The same hardness might be imparted to the white soap by drying it more, which would give it all the essential properties of the marbled.

Foreign Soft Soap.

The ley of potash is prepared in the same manner, and with the same attention as those of soda. They will have all the causticity that is required, if 80 lbs. of lime are taken to a cwt. of potash. This quantity of potash is in general sufficient for converting into soap 160 lbs. of oil.

The manufacturer ought to manage his boiler with all the precautions prescribed for the manufacture of hard soap. The whole of the ley which has been used ought to remain in combination with the soap; it is, therefore, necessary that it should not be suffered to separate from the paste, and that the latter should be prevented from clotting. The paste is reckoned to be sufficiently boiled when after cooling it is found to be perfectly united, and of a soft clammy consistence.

In manufacturing this species of soap care should be taken not to make use of any soda or sea salt. These substances tend to give a hardness to the soap made with potash, and would in fact render it hard if employed in sufficient quantity.

Some soft soaps are green or black. When oil of hempseed is employed, they are of a green colour without making any farther addition. If rape oil is used, yellow soap is obtained, the colour of which is changed into green by adding a small quantity of indigo during the boiling. When any colourless oils, such as that of linseed is used, a green colour may be given to the soap by the addition of a yellow and blue pigment; namely, turmeric for the yellow, and indigo for the blue. These different oils are usually employed mixed together, and the manufacturers have a habit of adding, during the boiling, a mixture of turmeric and indigo when they wish to have green soaps; and when black soaps are wanted of them, they colour them by adding, during the boiling, a quantity of sulphate of iron and decoction of gall nuts.

Hog's lard is also used instead of oil in manufacturing soft soap for the toilette.

White Curd Soap.

This is made of tallow only, and is the best of the English soaps in common use.

The boiler must be perfectly clean, and if 10 cwt. of best

home melted tallow is to be made into soap, add to it 200 gallons of ley. The fire must be moderate as the goods are apt to boil over. The boiling is continued about two hours, and the fire being withdrawn, the goods are left to settle for another two hours, and then the ley pumped off. As the ley separates quickly from curd soap, two or three boils a day may be given with ease, until the soap appears something like a curdy mass, and when pressed between the finger and thumb, forms a thin, hard, clear scale not sticking to the finger. Then withdraw the fire, add a few pails of cold ley, and when settled pump the ley clean off.

To wash this soap, light the fire and add 90 or 100 gallons of water. When the goods are melted and have boiled some time, try, on a board held sloping, if the ley runs from the soap, if so add more water; if it do not run, or there be no appearance of it, boil for a short time, then add about 3 gallons of salt and 6 of water mixed together, which will soon separate the soap and water from one another. When this is done withdraw the fire, and in about half an hour pump off the water, which will bring with it most of the remaining ley of the former boil.

The fire is again applied, 60 or 80 gallons of water added, and boiled for some time; examine if the water runs from the soap, if it does, add more water in small quantities, until instead of running from the soap, it appears only just starting from it. Then increase the fire so as to swell the soap up to the brim of the pan; withdraw the fire immediately, cover the pan to let it cool gradually for twelve or fourteen hours, or even longer. If the soap has the slightest blue cast repeat the washing.

The moulds for white curd soap should be lined with coarse cloth used only for this purpose. After it is put into the moulds and well stirred, the mould should be covered with coarse linen, matting, and the like, that the soap may cool slowly and uniformly. A cwt. of tallow is computed to make 3 cwt. of white curd soap; but it is seldom that so much can be obtained. The ley is usually made of 3 cwt. of American potash with 5 cwt. of barilla, but kelp is sometimes used, and as it contains much sulphuretted hydrogen, and other impurities, the water pumped off will be of a dark bottle green colour.

Thirteen cwt. 2 qr. 16 lb. of tallow, 5 cwt. 3 qr. 12 lb. of barilla, 3 cwt. 2 qr. 6 lb. of American potash, 4 cwt. 2 qr. 7 lb. of quick lime, and 3 qr. 16 lb. of salt, produced 24 cwt. 1 lb. of soap, with no more than 1 cwt. nigre or black ash.

White curd soap, scented by adding some oil of caraway seeds just before it is poured into the moulds, is in great use as a toilette soap, by the name of *Windsor soap*.

Tallow soap dissolved by heat in spirit of wine separates on the solution being cooled, and forms a *transparent cake of soap* at the bottom: this is used also as a toilette soap.

Yellow Soap.

This is the common soap of England, and differs from curd soap by having rosin and palm oil added to the tallow.

A pan is usually charged with 150 or 200 gallons of ley, and then 10 cwt. of tallow, and 3 cwt. of rosin, broken into small lumps, are added. The boilings are usually of two hours each, after which the fire is withdrawn, and the pan left for five or six hours to settle, as the ley does not separate so soon from yellow soap as from white soap; after which the ley may be craned or pumped off.

These boilings are continued until the soap is made, and forms a thin hard scale when pressed between the finger and thumb. Then give a quick boil, withdraw the fire, cool with 20 or 30 gallons of ley, and in two hours time draw off the ley; 60 or 80 gallons of water are then to be added to the pan, a brisk fire made, and the goods boiled until they appear like thin honey. Trials are then made upon a board whether the ley runs clear from the soap, if it does, more water must be added, and the boiling continued. If no ley runs from the soap, too much water has already been added. About 1 gallon $\frac{1}{2}$ of salt, and 3 gallons of water are then poured in. When the ley is seen just starting from the soap, 20 pounds of palm oil are added, and in about half an hour the fire withdrawn, the pan left for a couple of days to settle, and then poured into the moulds, where, in about three days, it will become solid enough to cut into bars.

Thirteen cwt. 11 lb. of tallow, 3 cwt. 2 qr. 18 lb. of rosin, 1 cwt. of palm oil, 6 cwt. 2 qr. 14 lb. of barilla, 1 cwt. 16 lb. of potash, 5 cwt. 9 lb. of quicklime, and 3 qr. 6 lb. of salt, yielded 26 cwt. 21 lb. of yellow soap, and 5 cwt. 3 qr. 4 lb. of nigre or black ash.

Mottled Soap.

This is made from yellow soap by adding copperas water, and afterwards some colcothar or Spanish brown, as already mentioned.

Soft Soap.

This differs entirely from the hard soaps, in that the alkaline basis is only potash: 100 gallons of this ley is put with 280 pounds of tallow, and when this is melted, 82 gallons of whale oil are to be added. The fire is then withdrawn for two hours, and afterwards re-lighted, and 20 gallons more of ley added,

and boiled until the soap is half finished, when 10 gallons more ley are added, and afterwards, at different times, and by small quantities, 10 gallons more ley. The fire is now withdrawn, and the soap ladled into barrels, firkins, or other casks.

Two hundred and seventy-five gallons of whale oil, and 4 cwt. of tallow, boiled first with 252 gallons of potash ley, containing 15 ounces and rather more of pure potasse in the gallon, and afterwards 294 gallons of potash ley, containing 1 pound $\frac{1}{2}$ of pure potasse to the gallon, added in separate parcels of 42 gallons each, produced 6400 pounds of soap; so that one-half was merely water.

SUGAR.

This is obtained from the juice of the sugar cane, which is conveyed from the mill to a clarifying boiler, of which there are generally three in a boiling house, used alternately. As soon as the clarifier is filled, the fire is lighted, and to every 100 gallons of cane juice, $\frac{1}{2}$ a pint of lime in powder is added. The liquor is heated and scummed, until the scum begins to rise in blisters, which break into white froth; but it must not boil: this generally takes forty minutes. The fire is then damped, the liquor left for an hour to settle, and then drawn off clear, into the largest of the three, or which is most usual, four evaporating boilers. Here the liquor is allowed to boil, and carefully scummed, until it is reduced so low as merely to fill the next sized boiler, where, if the liquor is not perfectly clear, a little lime water is added. When sufficiently reduced in quantity, it is ladled into the next boiler, and from thence, in due time, into the smallest, called the *teache*, where it is still farther evaporated, until it is reduced to a thick syrup, and the thread it forms, when taken from the ladle, between the finger and thumb, breaks when it is an inch long. From the *teache* the liquor is ladled into the coolers, of which there are generally six in a boiling house, 7 feet long, 5 or 6 feet wide, and 1 foot deep: the slower it cools, the larger is the grain of this *brown* or *muscovado* sugar.

All the above operations are carried on night and day without ceasing during the crop time. The clarifiers and boilers must be proportioned to the quantity of juice that the mill can grind, and the richness of the soil. Thirteen hundred gallons of cane juice from a rich soil, will make a hogshead or 16 cwt. of sugar, which would require more than double that quantity of juice from a poor soil. Some water mills grind with ease as many canes as will make 30 hogsheads of sugar by the week. Three clarifiers of 300 or 400 gallons each, are judged sufficient

for a plantation that makes from 15 to 20 hogsheads by the week: the boilers diminish gradually in size, and the teache usually holds from 70 to 100 gallons.

From the coolers the irregular mass of imperfect crystals, mixed with molasses, is put into hogsheads without heads, placed on a frame over a molasses cistern; eight or ten holes are bored in the bottoms of these hogsheads, and these holes are plugged up with the stalk of a plantain leaf. The molasses drains through the spongy stalk, and in about three weeks the sugar becomes tolerably dry and fair.

The molasses is used as the material for distilling rum.

Clayed Sugar, or Lisbon Sugar.

This is a half refined sugar, obtained by a more perfect drainage of the molasses than in muscovado sugar.

The drained sugar is taken from the coolers already mentioned, and put into conical earthen pots, placed in a frame with the points downward over earthen jars to receive the molasses. This point has a hole of about $\frac{1}{2}$ an inch over, closed with a plug, which, as soon as the sugar is cold and become solid, is removed, and the molasses drains from it. To get out still more of the molasses, the upper surface is covered with a layer of clay, moistened with water, which, oozing through the clay and sugar, carries with it the remaining molasses. By repeating the addition of moistened clay the sugar is rendered still finer and lighter coloured.

Refined, or White Loaf Sugar.

A number of processes are used for refining the muscovado sugar into loaf sugar, and from the extent to which the manufacture is carried, any improvement in it is a sure source of great profit to the inventor.

The usual method was to charge the boiler with lime water, to light the fire, and dissolve in the water the muscovado sugar that was to be refined; a quantity of eggs, or blood was then added and stirred in, which coagulating rose with the impurities of the sugar into the scum, which was taken off. The refined syrup was then poured into conical pots placed on their points, in which is a hole, stopped at first, but afterwards opened to let the treacle drain off. The top of the sugar was covered with wet clay, the moisture of which ran through the sugar, and carried off still more of the treacle. When the treacle ceased to drain off, the pots were set on their broad ends to diffuse the last remains of the treacle through the sugar, and then stoved for several days to dry the sugar perfectly. Sometimes the

solution of the sugar and purification were repeated twice or thrice.

The following improvements have been made in this process.

1. To moisten the raw sugar and press it before it is refined, much of the treacle is carried off, and some pure sugar, the remainder is left dry, whiter than before, and is much sooner refined. The liquid part not being injured by heat may also be made into an inferior kind of loaf sugar.

2. To heat the sugar pans with steam, either by enclosing the pan in a jacket, or by having a coil of pipe at the bottom of the pan; the jacket or pipe being filled either with steam at the ordinary pressure, or with high pressure steam in order that the syrup may be made to boil.

3. To heat the sugar pans by a coil of pipe, through which a current of hot oil is made to pass, by a forcing pump worked by a steam engine; the oil being heated in a vessel placed on the side.

4. To clarify the solution of sugar by adding from two to five pounds of bone black to each cwt. of sugar that is dissolved, previous to the addition of the eggs, or blood.

5. To remove the pressure of the atmosphere from the surface of the boiling liquid in the pan, in order that it may boil at a less temperature, and, therefore, that less of the sugar may be converted into uncrystallizable syrup, or treacle. This pressure may be removed either by means of covering the pan, thus converting it into a retort, and extracting the air by an air pump; or the pan being converted as before into a retort, the air may be driven out in Barry's method by steam, which, after having done this office, is then employed in heating the pan. The condensation of the steam raised from the pan is effected by Barry's patent by a condensor, upon the principles of Prof. Solimani's dephlegmator, as delineated in fig. 224, *h*.

6. To filter the evaporated syrup through numerous folds of canvas, by either removing the air by pumps from under the filters, and thus forcing the liquor through them by the pressure of the atmosphere. Or by closing the filtering chest at top, air is forced in by condensing pumps, and by its compressing power the liquor is forced through the filter.

7. Instead of lime only, sulphate of zinc is used to purify the sugar. The pan is charged with strong lime water, and the sugar added. When the sugar is all dissolved, four ounces of sulphate of zinc is taken for every cwt. of sugar, dissolved in as little water as possible, and stirred into the pan. If the raw sugar contains much acid, take one-fourth as much lime as of sulphate of zinc, mix it into a cream with a little water, and add it to the pan about five minutes after the sulphate of zinc, which

latter being decomposed by the lime, the oxide unites with the extractive matter, tannin, and gallic acid, and renders them insoluble.

8. In regard to the drainage, Mr. Drake puts a piece of damp calico upon the sugar in the mould, and on that two or three inches deep of plaster of Paris, mixed with three times as much water. This is renewed every other day for eight or ten days, or longer if the loaves are large.

9. Another method of drainage was founded by Mr. Howard on the principle of water, although saturated with one salt, being capable of dissolving another. In finishing, therefore, the lumps he poured on the sugar in the moulds, a syrup made as strong of sugar as possible, which dissolves the treacle as it passes through the mould, but leaves the sugar untouched.

Sugar is extracted also from other articles than cane juice, as from the sap of the maple by the American cultivators, the sap of the walnut tree by the Tartars, the juice of apples, or pears, the acid being previously saturated by chalk, and from beet root; but these are only substitutes employed when the cane sugar is, from accidental circumstances, not to be had but at a price much higher than usual.

Sugar is used as a sauce to many kinds of culinary preparations, as puddings, fruit pies, and dressed fruits. It is also used to sweeten many kinds of drinks. Considerable quantities are made into ale and wine, by being flavoured with other materials; it is also much used in preserving fruits and the other edible parts of plants; and as an adjuvant in preserving animal substances.

Syrups.

Formerly upwards of a hundred syrups were made and kept in large quantities in the apothecaries' shops; at present it is only the clarified syrup sold by the name of *capillaire*, and colouring, that are manufactured in large quantities; for the consumption of syrup of buckthorn by the farriers, and of syrup of violets by mothers and nurses, is greatly diminished.

The *capillaire* of the shops is made by dissolving in water the broad ends only of the sugar loaves without breaking or bruising them, as otherwise the syrup would be cloudy, adding to each pint of the syrup an egg broken in pieces, (the shell being put in not to lose the white sticking to it,) and after stirring the whole well together, giving it a boil and straining through a flannel, or rather a tamis. When cold, to each pint there is to be added about an ounce of either orange flower water or rose water, or both. Some, to give a rich appearance to the sy-

rup, dissolve gum tragacanth in it, but then it does not mix well with wine, the gum separating in threads. Capillaire is used to mix with fair cold pump water to form an agreeable summer drink, which is also esteemed highly restorative. Common capillaire, made with plain water only, is also made by publicans to sweeten their mixed liquors, as brandy and water, and the like, quicker than by putting in lumps of sugar.

Brandy colouring is another syrup of which great quantities are manufactured. Brown sugar is put into an iron pot, heated till it melts, and stirred till it becomes of a dark colour, and begins to grow bitter; lime water is then added to form it into a syrup, which is used to communicate a reddish brown colour to brandy, and this gives it the appearance of having been kept long in an oak cask.

FARINACEOUS SUBSTANCES.

Flour.

The mills which grind wheat for the London markets use three dressing machines. The upper part of the cylindrical sieve of the first machine is a wire cloth of 64 wires to the inch, the flour that passes through this is called fine flour; the other part of the cylinder has fewer wires and suffers a coarser flour, called middlings, to pass through it, while the bran and coarse pollard fall out at the end of the cylinder. The middlings are ground over again in a pair of mill-stones which are rather dull, and become unfit for grinding corn without dressing them again. Then, after this second grinding, the meal is dressed in the machine, called the bolter cloth, which allows the second flour to pass, and the pollard comes out at the end of the cloth. The bran and the pollard together are now put into the cleaning off machine, which is a coarse wire cylinder, and by it is separated into hog pollard, which is the finest sort, horse pollard, and bran. A pair of mill-stones, when in good condition, will grind five bushels of wheat in an hour; but require to be taken up and dressed once a week, if used constantly.

Accum says that 8 bushels, or 32 pecks of wheat, will yield 5 bushels 3 pecks of fine flour, 2 pecks of seconds, 1 peck of fine middlings, $\frac{1}{2}$ peck of coarse middlings, 3 bushels of 20 penny flour, 2 bushels of pollard, and 3 bushels of bran, being, in all, 14 bushels 2 pecks $\frac{1}{2}$, so that its bulk is almost doubled.

For household bread the corn is passed only once through the stones. A bushel of wheat of 61 lbs. produced 60 lbs. three-fourths of meal and bran, which, by dressing, were separated into 48 lbs. of household flour, being four-fifths of the wheat, 4 lbs. one-fourth of fine pollard, 4 lbs. of coarse pollard, and 2 lbs. three-fourths of bran, 2 lbs. being lost in dust.

For ammunition bread, the miller is required to furnish for every five quarters, or 2280 lbs. of wheat, 7 pecks, or 1960 lbs. of flour; this is 52 lbs. 7 oz. for 61 lbs. of wheat, or nearly five-sixths.

The millers about London and other sea ports, reduce their flour to the price of the market by mixing with English wheat or flour, foreign or American, as also Indian meal and rye; for buck wheat is too scarce and millet too dear: they can also sell their pollard for gingerbread and brown biscuits. The inland mil-

lers cannot obtain the same price for their flour, and are obliged to reduce it by grinding about one-third of beans with the wheat. Having scarcely any sale for their pollard, they are necessitated to buy hogs to eat it up, and fatten for the knife. Both sea-port and inland millers feed their horses upon bran as they have no vent for it.

Liquid ammonia, the liquor ammoniac purg of the chemists and druggists, poured upon wheat flour turns it yellowish, but if any other flour is mixed with it the colour is more or less brown; and if peas and beans are used by the miller, the colour produced is dark brown.

Millers are accused of adding bones, plaster stone, whiting, and Derbyshire white with their flour; but this accusation is false, as these additions would be instantly detected by the baker, from the flour after being squeezed in the hand breaking down immediately. Flour has, indeed, been manufactured with these substances for the purpose of cheating government, by depositing it in their warehouses in the place of so much foreign corn taken out without paying the duty, and becoming intentionally forfeited has been seized, sold, and thus found its way into the market.

Sand is also mentioned as an intentional adulteration of the flour by the miller, but all flour ground between stones necessarily contains some of this substance from the wear of the stones. Lately this detriment has been more abundant than usual, as during the war the millers could not obtain the hard buhr-stones from the banks of the Rhine, and were obliged to use soft Welsh stones, or even common sand stones, which wore down very fast. The mill-stones in Switzerland are extremely soft, and the sand mixing with the flour is thought to occasion the bowel complaints so common there.

Many families in the country grind their corn in small mills at home. Steel mills cut the corn rather than grind it, and hence they introduce much of the bran into the flour. Williams' mill (Trans. Soc. Arts, for 1814) in which the side of a cylinder of French buhr-stone works against a breast-stone on a moveable carriage, is an excellent family mill, though it grinds slowly. Rustall's family mill (Trans. Soc. Arts, for 1800) in which a small circular stone is turned vertically against another, grinds double the quantity. His box for the sifting the flour should have two or three sieves of different fineness, for it is a bad practice to pass the corn only once through the mill; it should be ground twice, the stones not being set close the first time, by which means the corn being only crushed, a large clear flake bran is obtained. The fine flour obtained in this grinding being sifted from the middlings and bran, may be reserved for pastry, without much injuring the colour of the remainder, especially if the middling flour being sifted from the bran in a coarser sieve is ground over again, the stones being set closer to improve its quality. The greatest inconvenience of these family stone mills is, that when they wear smooth there is some difficulty in getting them repicked. When a family grinds their corn at home they can mix their wheat with buck wheat, and thus greatly improve the flavour of their bread.

Bread.

Three kinds of bread may be distinguished. In the first, called *unleavened bread*, flour and water is kneaded, either by themselves or with eggs, butter, sugar, and some other articles, and exposed to heat or to the open air, by which the dough is reduced to a very solid mass, which is sometimes flakey, but never cellular or spongy.

In the second kind of bread, called *leavened bread*, the flour and water being mixed together, is either left for some hours in a thin and almost liquid state, that the sugar existing in the flour may be spontaneously changed into alcohol and carbonic

acid gas, and by their expansion by heat, render the bread, when baked, spongy and light: or it has certain substances, called *ferments*, added to it, which accelerate the fermentation of the dough, and cause it to take place simultaneously throughout the whole mass of dough.

In the third kind of bread, a cellular appearance is given to the bread by adding certain substances to the mixture of flour and water, which give a cellular appearance to the bread when baked, by the mere expansion of the gas disengaged from them by the heat, without producing any change in the constituent parts of the flour. As this kind of bread is seldom made, unless a baker has a sudden call for a greater quantity of bread than he can supply in the ordinary way of business, it has had no peculiar name given to it.

Different flours and mixtures of flours vary in the quantity of bread that can be made from any given weight of them, and it is commonly thought that the flour or mixture that produces the greatest weight of bread is the most profitable. Certainly it is so to the public baker, who, if he can sell this bread at the same price with that producing a less weight, receives from his customers the value of the increased weight for mere water. But housekeepers who make their own bread, ought to prefer that flour or mixture which drinks up the least water in being made into bread; as these loaves, although less in weight, will go farther in satisfying the appetite: besides which, the middle part of bread that contains superfluous water, crumbles away under the knife, and much is wasted in this manner. The preference given to white bread in towns, even by the poor, is thought to be owing to luxury; but, in reality, as white flour drinks up less water than the brown, the white bread is more economical than the brown; and the preference given to it arises from observing that the weekly expenditure for bread is less for the best white bread than when cheap bread or brown bread is used for a constancy.

Much of the goodness of bread depends also upon the kneading, which is of two very distinct kinds. In the kneading used by the English and French bakers, much air is introduced into the dough. The closed fists are slid under the mass in the trough, and the hands being then opened, a quantity of the dough is brought from the bottom of the mass and dashed down to the other end of the trough, this manœuvre is repeated until the whole of the dough has been turned over. The smallest number of these turns used by public bakers is four, six is the general number, and for choice bread eight: some have even given twelve. By this introduction of air into the dough, it would appear that an acid, either the acetic or lactic, or even

both, is generated in the mass, the sour smell being very perceivable in a bake-house; as well as a portion of sugar, since the proportion of sugar extractable from the bread is greater than from the flour, notwithstanding the necessary expenditure of the greater part of the sugar of the flour in the fermentation and rising of the dough.

In the other method of kneading; or rather pressing the dough, sugar alone seems to be generated, as may be judged from the sweetness of the products. This method of pressure is used in treading the dough for sea biscuits, and little or no air is introduced, particularly in the French method, where the dough is covered with two cloths; the sweetness of these biscuits is well known. At Bologna, Venice, nearly all Lombardy, and Rome, with its neighbourhood, the dough is kneaded with a gramola, or indented pestle, like the dolly of our laundresses; the bread thus made is described as less spongy than the common bread, but so much sweeter that it may be, and is eaten as a cake, by itself. Vermicelli and the other Italian pastes are merely pressed by the brie, and although not exposed to any fire, but dried in the air, they are very sweet tasted, particularly vermicelli. The imperfect kneading given to home-made bread by the cooks rather pounding the dough with their fists than kneading it, is the cause of its sweetness to some palates.

What effect is produced by the mill of Geneva, to which all the bakers in that town are obliged, to their great loss of time, labour, and convenience, to send their dough to be kneaded, has not been published.

Leaven.

The mixture of flour and water will enter into fermentation, but this action proceeds very slow: 4 ounces of wheat flour, with a pint of water, kept in a warmth of 70 deg. Fahr. took four days before it began to ferment. Another mixture made in the heat of summer, began to ferment in thirty-six hours, and in some days it became sour, and on being used to cause the fermentation of fresh dough, the dough speedily became sour. The addition of an ounce of salt, or the impregnation of the dough with carbonic acid gas, neither impeded nor promoted the fermentation. By taking only 8 oz. of flour and 2 pints of blood-warm water, and as soon as the sponge begins to rise, on the second day, adding 1 lb. of flour and 4 pints of water; and thus proceeding for a day or two, an original ferment will be obtained, which being added to the mixture of flour and water, for making bread, will determine the fermentation to take place in three or four hours. It is probable that this

fermentation would take place quicker if a little brown sugar was added, or if millet flour was used, as this is so much sweeter than wheat flour; rye flour is also more easily fermented than wheat, but has a tendency to turn sour.

It is only under peculiar circumstances that a recourse to an original ferment is necessary, for this ferment having been once obtained, and the dough nearly ready for baking made from it, the fermentation of the next parcel of bread is readily put in action by reserving some of the fermented dough, and using it for that purpose. It is more than probable that the original ferment of the bread made throughout France, Spain, and Portugal, was produced many centuries ago in Carthage, from whence the use of bread was introduced into Europe, on the destruction of that city.

To preserve this reserved dough, or leaven as it is called, from growing sour, several methods are adopted. In the north of England, the leaven for the next week's baking is kept fit for use by being buried a few inches deep in a sack of flour. In Italy it is kept fresh even for three months by being buried very deep in flour. The French, if they intend to use the leaven in a few days, keep it in a warm place between two bowls, and add every day as much flour as the leaven weighs, and a sufficient quantity of water to restore the original consistence; but if it is not to be used for a week or longer, the scrapings of the kneading dough is cut into small pieces, dried by a gentle heat, and when wanted, rubbed down with warm water.

Except in a few farm-houses the fermentation of the dough is promoted, throughout the whole of the north of England, by the scum that arises in the fermentation of malt liquors. This yeast or barm is generally used in the proportion of a pint to 100 lbs. of flour, and produces the fermenting action in the dough quicker than leaven. In general the yeast is dissolved in the first parcel of water with which the flour is mixed, and no leaven is used: but at Paris, and other great towns in France, the dough is made with leaven, and a little yeast is added to the last parcel of water, merely to increase the sponginess of the bread.

If yeast is not to be purchased, original yeast may be obtained by boiling a quarter of a peck, 3 lbs. and a half of meal, for eight or ten minutes, in three pints of water, and pouring off two pints, which is to be kept in a warm place; the fermentation will commence in about thirty hours. At which time four pints more of a similar decoction of malt are to be added, and when this ferments, another four pints are to be added; and so on, until a sufficient quantity of yeast is obtained.

The French, under the name of *levure*, comprise not only yeast but the bottoms of the beer, in the working tun and store casks. This is purchased by the yeast merchants, the beer drained from it through sacks, and the remainder of the beer washed out by putting the sacks in a stream of water; and the solid matter left in the sacks is dried in the open air. The true yeast, or flowers of the beer, is also drained and dried for use in the same manner, as most of the Paris bakers prefer it in a solid state.

Dry *levure* ought to be yellow, brownish, or grayish white, by no means black or bitter. It should not yield to the pressure of the fingers, and be equally dry throughout, so as to break with a smooth surface. When dissolved in hot water, and a few drops of the solution are poured into boiling water, they should immediately rise to the surface.

In Edinburgh the bakers multiply their yeast daily by mixing 10 lbs. of flour with 2 gallons of boiling water, and covering it up for about eight hours. Two pints of yeast, made the day before, are then stirred in, and in about six or eight hours as much new yeast will be generated as is sufficient for 1 sack and a half, or 420 lbs. of flour.

When original yeast is prepared from malt, the fermenting wort may be added to the flour as well as the yeast, according to Mr. Stock, whose patent substitute for yeast is merely wort in a state of fermentation. The wort being

made from 2 lbs. of malt, one-fifth of an ounce of sugar, and 1 ounce of hops, to each gallon. Two gallons of this wort are sufficient for 12 bush. or 540 lbs. of flour.

The Hungarians prepare a similar ferment for keeping all the year, by boiling in water in the summer, wheat bran; obtained in grinding for household flour, along with hops; the decoction soon ferments, and then a sufficient quantity of bran is flung in to drink up all the liquid, and allow it to be formed into balls, which are dried in a gentle heat. When wanted for use, some of these balls are broken, and boiling water poured upon them, which after some time is strained off, and used to make up the dough.

In like manner the Romans prepared their ferment, by drawing off in vintage time, a quantity of grape juice while at the height of its fermentation, pouring into it a sufficient quantity of millet flour to drink it all up, and forming it into small balls, which when wanted were broken, infused in boiling water, and the whole was mixed with the dough.

A similar ferment may be prepared in this country from raisins; the raisins must either be pressed between boards with a heavy weight, or mixed up with the ground millet, as otherwise the strongest part of the must would remain amongst them.

In summer the leaven, yeast, and even dough, is apt to turn sour, and gives a sour taste to the bread; this is remedied by stirring a few tea spoonsful of carbonate of magnesia into the ferment or dough. The Swedes, however, prepare a sour yeast to ferment their sour sweet bread for summer use. Into a small barrel, open at one end, which the oftener it has been used for this purpose is the better, they put some rye flour, and pour on it boiling water to form a thin sponge; to this they keep adding by degrees more rye flour and boiling water. It quickly ferments, and as it swells is allowed to run into a bowl by a faucet which is driven into a hole in one of the staves near the top.

It has been affirmed that flour kneaded with water saturated with carbonic acid may be made into bread without any yeast, others deny it: the difference in these assertions, probably, depend on the method used in forming the sponge. As flour and water will ferment of themselves, but the dough turn sour before it is fit for use, it is probable that the use of water saturated with carbonic acid gas may, if the sponge be made very thin, determine this fermentation quicker, and enable the sponge to be brought forward by degrees, to a fit state for making dough of the requisite stiffness.

When the baker has not sufficient dough ready for the oven, the deficiency is made up by dissolving for every four pounds of flour 1 ounce $\frac{1}{2}$ of volatile salt, the common subcarbonate of ammonia, in the water, intended to make the dough. This being properly kneaded may either be baked immediately, or in a short time. This bread is porous rather than spongy and bladdery, the cells being numerous and excessively minute. It has a slight tinge of yellow, and a slight unpleasant flavour, scarcely perceptible if the baking has been properly performed.

The oven, or furnace in which the bread is baked is generally built of brick in this country, but on the continent they prefer stone, as being easier and more regularly heated, and retaining the heat longer. Our ovens are circular, from three to twelve feet in diameter, and the crown of the arch is from two

to three feet high, the door being twenty-four inches wide, and twelve high, arched at top. Most persons are fond of large ovens, on the supposition that they require less fuel to heat them; but two or more small ovens will, however, be found far preferable, even by public bakers. In London, where baking of meat and pies forms a large part of the baker's business, and the oven must be kept hot during the whole of the day, the heat is retained by making a fire place on one side a little below the level of the floor of the oven, from whence a flue passes in several turns under the oven floor, and then round the side, from whence it passes into the chimney.

Mr. Losh's experiments, as already related, show the advantage of having a fire grate near the back of the oven, to give air to the fire behind. In the large French army ovens, and those of Germany, three or four holes, three inches by four, are made in the walls of the oven towards the back, even with the floor, for the same purpose, and when the fire is at its height they are closed with stone plugs and wet rags.

The great inconvenience of the common brick oven is, that it does not act well unless it is kept in such constant use as not to be suffered to grow quite cold, or even considerably cool. When heated from a cold state, the first batch of bread is never so well baked as the succeeding batches; and hence some public bakers only bake a small quantity of inferior bread for their first batch. There is also a great waste of fuel in suffering the oven to get cold, for it takes three times the fuel to heat a cold oven, as it does to keep up the heat for the succeeding batches, supposing they follow each other quickly.

The perfection of fermented bread consists; first, in its exhibiting when the loaf is cut through, a pile of bubbles, or air cells, gradually increasing in size as they approach the top, where they should be very large: secondly, in the middle of the loaf being equally dry as the part of the crumb next the crust, and not crumbling when cut. The first depends on the bread being thoroughly penetrated by the heat before the crust is too hard to rise, and, therefore, this pile of bubbles can seldom be obtained except when brick or stone ovens, which have been some days in heat, are used, and the door kept closed. The second shows that the bread does not retain, either from deficient baking, or the nature of the flour, or mixture of which the bread is made, a superabundance of water, which increases the weight of the bread without adding to its nutritive power, 15 lbs. of good wheaten flour ought not to drink up more than 10 lbs. of water, to form a dough, which, when properly baked, will produce at most 20 lbs. of bread.

London Bread.

The most usual mode of making of yeast bread by the London bakers is to dissolve from 4 lbs. to 6 lbs. of salt in 36 lbs. of hot water, and when the solution is cooled to about 84 deg. Fahr. 3 pints of yeast are added. In the mean time a sack, 280 lbs. of flour, is sifted into a box with a lid so as to lie light, and a hole being made in the flour the above seasoning is added, mixed up to the consistence of batter, covered with flour, and the box being shut is covered with flannels. The quarter sponge thus set is left for three hours, another 360 lbs. of warm water is then added, and more of the flour kneaded into the mass, or half sponge. When this sponge has been set about five hours, the remaining portion of warm water, generally 108 lbs. is added, the whole mass of flour well kneaded with it for more than an hour, then cut to pieces and confined to one end of the box, and covered with a sprinkling of flour. In four hours it is kneaded again for half an hour, and cut into loaves, which are immediately put into the oven which is judged to be properly heated, when some flour thrown on the floor of it becomes black very soon without taking fire: loaves are placed so close together as when they expand by the heat they squeeze one another into a cubical, or oblong form. They remain in the oven about two hours and a half, and the bread when taken out is covered up to prevent, as much as possible, any farther loss of weight, which in the baking is about one-ninth of the weight of the dough, although it has increased in size to three times its dimensions.

The sack, 280 lbs. of good flour, is calculated to make on an average, 80 quartern loaves; or 347 lbs. $\frac{1}{2}$ of bread; but as flour varies in its power of absorbing water, so a sack of ordinary flour will sometimes make 86 loaves by absorbing 34 lbs. 2 oz. of water more than in the former case.

In London, about half a pound of alum is put into the seasoning in the place of as much salt; this is supposed to make the bread whiter, and to hinder the loaves from adhering too fast. Some bakers in poor neighbourhoods are said to make their seasoning half alum and half salt.

If the leaven should turn sour, as will sometimes happen in summer, it will be necessary to sift some magnesia into the flour with which it is to be mixed.

The mistresses of families in London exert themselves to confine the consumption of this bread to 6 lbs. at the utmost by the week for each person in the family, or about 13 ounces $\frac{1}{2}$ for each daily; and if rolls or other bread is bought, or much flour consumed in making puddings, the consumption of this

bread is expected to be proportionally less. As it is at present a great point in English economy to discourage the consumption of bread and encourage that of meat, this bread is seldom eaten till it has been made 24 or 36 hours, and become hard and dry, so that it will require considerable mastication, and thus a less quantity will satisfy the appetite, than when new.

The yearly consumption of butcher's meat in England is estimated at 250 lbs. or about 12 oz. a day for each individual; while in France the yearly consumption of each individual is estimated at only 8 lbs., or little more than $\frac{1}{4}$ oz. by the day. The real fact is, that only about one-third of the population ever taste butcher's meat; the lower classes and a great part of the middling, using mushrooms of many various kinds to communicate the meat flavour to the roots and pulse which form the substantial part of their food, while in England these are only esteemed as auxiliaries to the meat.

A few London bakers endeavour to make their bread fine and white; but the greater part take little pains to make good bread, because the great use of pies, baked meats, and baked puddings in English housekeeping, and the general want of ovens in the London kitchens, occasions bread to be bought of the nearest baker, although it is confessedly worse than that made by another at a small distance farther, for the sake of not having so far to carry or fetch the pans.

Home-made Bread.

Household bread is made of household flour. It is now seldom made by the public baker, but usually by those families in the country who bake their own bread. As the brown flour retains more water after baking than the white, this bread of course does the same, and hence it keeps moist longer than white bread, but the middle crumbles away. The deficient kneeding it usually receives, gives it an anomalous taste which some call sweet, others sour. Being unsatisfactory to the appetite, the good lady of the house flatters her self-love in observing the increased appetite of her London guests, and ascribes it to the excellence of her home-baked bread, that which arises from its imperfection.

Home-made bread is most commonly baked in brick or stone ovens; but as these are seldom kept constantly in heat in private houses, the bread is always imperfectly baked, and loaded with superfluous water. The only way to avoid this would be, to employ the oven daily in as many of the operations of cookery as possible. Stewing, boiling, frying, and even broiling on a gridiron, placed over an iron dripping pan, may be performed in an oven nearly, if not quite, as well as on a range. But as this would make a great alteration in kitchen management, it is preferable for small families to bake their bread in an iron oven. An oven of this kind, 20 inches from

front to back, 16 inches wide, and as many high, will bake rather more than 20 pounds of bread at a time, each baking taking up two hours. In baking two batches of bread successively in a sheet iron oven of this size, which had been in use for fifteen years, the time from the first lighting of the fire being five hours, there were consumed 6 pounds of Walls' end coal, 3 pounds of cinders, besides the wood used to light the fire. This oven was placed 14 inches above the grate of a fire-room, 10 inches from front to back, 7 inches high, and $7\frac{1}{4}$ inches wide, widening each way at top to $1\frac{1}{2}$ inch on each side beyond the oven. If an oven of this kind, instead of being closed at top by a brick arch thrown over it, be covered with a flat cast-iron plate, stewpans, saucepans, and frying-pans, may be placed thereon, or flat cakes baked on it: and if a double sheet iron dish cover be placed upon this plate, a second oven, useful for baking small pastry, puddings, or potatoes, will be formed.

For baking at home, upon a smaller scale, Holmes' oven, which is a plain cast-iron closet, generally 15 inches deep, and 13 wide and high, with a couple of sliding shelves, and having on the outside of one of its sides a cylindrical lump, about 8 inches long, and 2 wide, projecting from it. This oven being fixed on one side of the kitchen range, so that the lump of iron may project into the fire, a sufficient degree of heat is communicated to the oven to bake small loaves, pastry, potatoes and pans of meat, or heat dishes and plates, without giving the cook the least trouble. If hot closets of this kind were neatly adapted to the stoves in dining parlours, plates or dishes might be kept warm in them, instead of plate warmers, which hinder the radiation of heat into the room.

Those false economists who estimate the value of bread by its own weight, instead of that of dry flour it contains, have endeavoured to increase the weight of the bread by boiling, for example, 5 lbs. of bran in 4 gallons of water, so as to strain 3 gallons $\frac{1}{2}$; 56 lbs. of flour made into bread with this water is said to have produced 83 lbs. of bread, while the same weight of flour with plain water produced only 69 lbs. $\frac{1}{2}$; hence the bran water loaves must have retained at least 12 or 13 lbs. of mere water in them more than the others.

Others have sought economy by mixing pulped potatoes with flour, and it is stated that 16 lbs. of raw potatoes boiled, peeled, pulped, and kneaded with 26 lbs. of flour, produced 40 lbs. of bread; now as 3 lbs. 3 oz. of farina can be obtained at the utmost from 16 lbs. of raw potatoes, this bread must have retained about 8 lbs. more water than is contained in fine wheaten bread.

Sea Biscuits.

In making the best sea biscuits, or American crackers, the fine stiff dough, on being beaten or rolled out on a dresser, with a mallet or roller, is doubled again, rolled or beaten, and

the doubling repeated several times, by which means the biscuits split into flakes when broken.

The common biscuits used on board English ships by the name of bread, differ only from American crackers by being made of pollard. The dough is made up very stiff, without either yeast or salt, and as it extends on being trod upon the floor, or beaten on a table with a brie, the edges are cut off with a spade, re-placed upon the mass, and again trod or beaten down, to render the bread flaky when baked. The baking is performed in very low arched ovens, or rather muffles, 20 feet in length, or even more, open at both ends, and the arch heated by flues from a fire at each end, but upon opposite sides. The biscuits being previously pricked, are put in at one end, on iron plates, connected together by hooks and rings, or to an endless chain. The plates, as fast as they are filled, are drawn through the oven, and by the time they arrive at the other end, the biscuits are fit for use. These biscuits are very inferior to the leavened biscuits supplied to the French ships.

Gingerbread.

Gingerbread is made by dissolving $\frac{1}{2}$ ounce of potash and a little alum in warm water, which serves to melt 1 ounce of butter, and mixing up with them 1 lb. of fine pollard, $\frac{1}{2}$ lb. of treacle, and an ounce of mixed spices, into a stiff dough, that requires to be put by for several days before it rises sufficiently to be put into the oven, and if kept even for many weeks is manifestly improved. The mixed spice is principally composed of ginger, to which is added cinnamon, nutmeg, and allspice; in the inferior kinds common pepper, and in the best and warmest sorts Cayenne pepper. Caraway seeds, anise seeds, currants, and sweatmeats are also added occasionally.

The alum is not necessary, for the gingerbread is equally good if it be omitted; it is put in to hasten the ripening of the bread for the oven, for this cannot be done by means of yeast as in ordinary bread. The butter might also be omitted, but it improves the flavour. The potash, when this bread is eaten in any quantity, cannot but have some injurious effect upon the health, and yet the presence of an alkaline carbonate seems necessary to combine with an acid in the treacle, and thus by setting free the carbonic acid, causing the gingerbread to rise: its place may, according to Dr. Colquhoun's experiments, be advantageously supplied by the subcarbonate of magnesia, usually called magnesia, in the same quantity, and the alum omitted entirely.

The substitution of magnesia for potash is attended with a

farther advantage, that by increasing its proportion the bread will be ready for the oven almost immediately. Flour and treacle, of each 1 lb., butter an ounce, and an ounce or 1 ounce $\frac{1}{2}$ of magnesia, with the usual spices, made a good bread fit for baking in a few hours' time.

By disengaging the carbonic acid from the magnesia by the tartaric acid, gingerbread may be got ready for the oven in less than an hour. Two pounds of flour, mixed with $\frac{1}{2}$ oz. of magnesia, and the usual spices, and made up with 1 lb. $\frac{1}{2}$ of treacle, 2 ounces of butter, and the requisite quantity of water, in which $\frac{1}{2}$ ounce of tartaric acid is dissolved, is fit for the oven in half an hour. Instead of tartaric acid, cream of tartar may be used, for 4 lbs. $\frac{1}{2}$ of flour, mixed with 1 oz. $\frac{1}{2}$ of magnesia, and the usual spices, and made up with 2 lbs. $\frac{1}{2}$ of treacle, 4 oz. $\frac{1}{2}$ of butter, and the requisite quantity of water, in which 6 oz. of cream of tartar have been dissolved, was ready for the oven in less than an hour, and the bread was well risen, but had a slightly sour taste, which some might esteem as an improvement.

The sesqui carbonate of ammonia, volatile salt, being used instead of potash in the common process, and the alum omitted, the bread is no sooner kneaded than it is fit for being baked; and the gingerbread is extremely well flavoured, only the upper surface is unusually dark and glossy. The same effects take place if a small proportion of volatile salt is added at any time to the ordinary gingerbread dough by the baker, if it is not ready when he wants it.

French Bread.

The public bakers in France usually begin their bakings of several batches, (5 in the morning,) by adding 5 pints of water to 3 lbs. of leaven, which they reserved from the last baking, and a sufficient quantity of flour to make their first sponge, which usually weighs 17 lbs. $\frac{1}{2}$.

Five or six hours after, (10 in the morning,) 10 or 11 pints more water is added, and flour to compose the second sponge, of 40 lbs.

Five hours after, (2 or 3 in the afternoon,) a pail, or 24 pints of water, with flour, are added to form the last or finished sponge, which will weigh about 120 lbs. About 3 lbs. of this sponge are taken out and put between two wooden bowls, to form the leaven for the next morning.

One hour and a half afterwards, (4 in the afternoon,) 3 pails $\frac{1}{2}$ or 4 pails, about 70 or 80 pints of water, and about 100 lbs. of flour are added, which will make about 300 lbs. of dough.

As the first batch is seldom so well baked as the following batches, many bakers use only $\frac{1}{2}$ a sack of flour, (160 lbs.,) in this batch, with leaven and water in proportion.

The dough being well kneaded, 80 lbs. of the dough are taken out for forming the sponge of the next batch, which is placed aside until the dough now made is put into the oven.

The French dough is made so very thin, that the loaves will not keep their shape until they are put into the oven; hence they are obliged to be kept in a cloth in a basket that will just hold them separately. They are also baked separate, that they may be crusty all round.

The flour for the second batch being put into the trough, a hole is made in it, and this reserved 80 lbs. of dough is put into it, and left for about two hours, water is then added, with which the reserved dough is diluted so that no lumps can be perceived, and is then worked with the new flour for the second batch; 80 lbs. being reserved as before for the third batch.

In this manner ten or more batches are made by most bakers: others continue on for forty or even fifty batches in two days and nights, without making fresh sponge as at first, but refresh the dough every other batch after the fourth with a petit levain or bye sponge. They take out of the third dough, besides the 80 lbs. for the fourth batch, about 12 or 15 lbs. which they immediately mix with as much water, and the necessary quantity of flour, to form the bye sponge for the fifth batch; and in like manner they take out of the fifth batch of dough a bye sponge for the seventh batch, and so on. These bye sponges are rubbed down with water, and added after the reserved dough has been worked up with the new flour.

Salt is seldom used in making bread in France, except for those kinds that are made for soaking in soup or broth, being thought to promote their dissolution, and then 1 oz. for each 20 lbs. of flour is the usual proportion.

If the bread is to have any salt or yeast put into it, this last dough is made up stiffer than is required for the bread to be made from it; and when it has risen sufficiently, the salt and yeast are dissolved in a sufficient quantity of warm water to bring the dough to the requisite consistence, and this water is kneaded into the dough, which is then set by to rise properly, and when ripe for the oven is made into loaves, and immediately put into the oven, being at this moment brushed over with water, to which some bakers add a little honey, yolk of egg, or milk. Yeast or levure is only used by the French bakers for the sake of making the dough in less time, as it renders the bread less white, and the bread not to be so good tasted as the

bread made with natural leaven; but the working bakers prefer yeast as diminishing their manual labour.

A quarter of a pound of yeast is esteemed equal in effect to 8 lbs. of leaven: it requires 4 oz. of yeast for 20 lbs. of dough, if no leaven is added.

After the yeast has been added, the dough is no longer fit for leaven, as it will not keep.

The usual consumption of a French family is estimated at 9 lbs. of soft bread by the week, together with 7 lbs. of soup bread, being in all 2 lbs. $\frac{1}{4}$ for each person by the day; a much greater quantity than is used in England, even if the flour used in making puddings and pie crust is added.

French Sea Biscuit.

The French sea biscuit is sometimes made by adding to each 100 lbs. of flour, 10 lbs. of leaven older than that used for bread, and a sufficient quantity of hot water to form a very stiff dough, which requires to be kneaded by the feet. But, at present, it is more usual to add to the flour half its weight of new leaven, and to make the dough thinner, so that it may be kneaded by the hands for an hour.

The biscuits being weighed and flattened, are exposed in a cool place until the whole are ready, and then baked. The oven is heated less than for bread, and as the biscuits are put in they are pricked in several places. The baking takes two hours. No salt is ever put into sea biscuits, that they may not attract moisture.

These biscuits are very brittle, dissolve easily in the mouth, or in soup.

German Bread.

The German white bread, or *semeln*, is made of fine white flour, and with yeast. The flour is mixed only three or four hours before it is to be baked, as the sponge is only refreshed once, and sometimes not at all. The loaves are very small, the large *simnel* weighing only half a pound; these are circular, and joined two or three together; but the best *simnel* is made in two ounce loaves, oblong, and joined five or six dozen together. The large *simnel* are baked first, and remain in the oven about half an hour; the small *simnel* is then put in: both are brushed over with water as they enter the oven; and some lighted small coal being put at the mouth of the oven, some water sprinkled upon it, and the door shut, the crust acquires a fine brown colour.

Scarcely any white bread made in Germany, except *simnel*, is made of wheat flour only. *Lockewitz* bread, esteemed next to *simnel*, is made by mixing dough made of wheat flour and yeast, with an equal weight of dough made of fine rye flour and leaven, kneading them together, and forming the dough into small loaves.

The German ovens are generally oval, with the door at one end, 10 or 12 feet from front to back, and the crown of the arch 5 or 6 feet high. As the ovens are so deep the loaves at the back cannot be arranged quick enough by the peel, and therefore young girls are employed to creep into the oven and arrange them. These oven-girls are enabled, by use, to bear the heat for several minutes. In Prussia the ovens are often floored with cast iron slabs: these might be advantageously adopted in the London flue ovens.

Wheat Starch.

This is made from wheat by treading it in sacks in a current of water; the water being received in troughs is left to ferment; which decomposing the saccharine substances, renders the starch that is deposited, on standing, very pure and white: friable, easily pulverized, crimp between the fingers, without smell or taste.

Foreign Starch.

This is made from the pollard and bran of wheat left after sifting away about half its bulk of the finer flour.

Potato Starch.

It is prepared from raw potatoes, especially those which have been spoiled by frost; very white, globular, crimp, friable, heavy: when held towards the light it has shining particles in it; dissolves in boiling water as easily as arrow root; 100 lbs. of potatoes yield from 10 lbs. to 14 lbs. of starch; which is sold for arrow root, and German rice flour.

Potato Flour, Potato Farina,

Is prepared from boiled potatoes; it is scarcely soluble in water; and is manufactured into sago, saloop, maccaroni, vermicelli, semolina, and tapioca.

Potato Tapioca.

This is made from potato starch; by boiling it before it is dried, stirring it to break it into lumps.

PRODUCTS OF MILK.

The products of milk form most important manufactures in almost every country, either in the form of butter or of cheese; although in the neighbourhood of great towns it is generally most profitable to sell the milk in its raw state. It is supposed that the same quantity of milk that will sell for 6*d.* will yield about 4*d.* if made into butter, and only 3*d.* if made into cheese, including the value of the pork, which is generally fed or fattened on dairy farms.

The milk of the cow is best adapted for making butter, as it yields more than twice as much cream as ewes' milk; but this latter milk affords a larger proportion of curd than cows' milk, and is, therefore, best adapted for making cheese. The ewe, however, is not worth milking, except where labour is very cheap, in proportion to the price of butter and cheese.

The manufacture of cheese is best carried on in summer; that of butter in winter.

The average produce of a grass-fed cow is calculated at five gallons of milk by the day, from the cream of which about 32 ounces of butter may be obtained; by feeding cows in the house this produce may be increased, but the labour is also much increased.

Butter.

The manufacture of this article depends greatly on the quality and quantity of the cream which can be obtained in the first place from the milk.

Cows yield more milk when milked three times a day than when milked twice; whether they would bear milking oftener, and whether the produce of butter is increased by this frequent milking is not yet ascertained. The milk of some cows yield more cream than that of others; a cow which had been kept for several years amongst others, when sold to a person who kept only one cow, was found to yield no butter whatever, although the milk appeared very rich. The first half of the milk drawn from a cow which has missed having a calf that season is very commonly sensibly salt, while the latter half is perfectly sweet. Turnips, cabbages, and some other kinds of food affect the taste of the milk, but whether this disagreeable taste is confined to the first drawn milk is not yet ascertained. The cream yielded by the last half of the milking, if the udder is properly emptied, is not less than eight, and sometimes sixteen times as much as that yielded by the first half of the milking, the average is probably ten or twelve times that much. Water added to milk causes it to throw up a larger quantity of cream than if unmixed,

but the cream is of a very inferior quality. Milk carried to a distance before it is laid by for cream, or any other way shaken, yields much less cream, and also thinner than that which has not been agitated.

Cream which has not acquired the proper degree of sourness before it is churned, requires in summer long continued churning, and is generally soft, tough, and gluey; and in winter, the butter will scarcely be formed unless heat is applied, and then is of bad quality, white, hard, brittle, and with very little flavour. The stroke in churning must be kept on regular, as a few hasty strokes will render the whole of the butter of scarcely any value. If the milk that drains from the cream is carefully separated, the cream may be kept for a long time, even many weeks, perfectly good. Butter washed, or only kept in water, is greatly debased in its quality, and will not keep good for any time. The quicker the milk turns sour the better.

These observations of Dr. Anderson and others show the method to be adopted in milking cows, and setting by their milk for cream. The cows should be milked close to the dairy door; as soon as half the milk is drawn from each cow it should be strained into a cream dish, which of course need contain only two gallons, and should never exceed three inches in depth. Wooden dishes are to be preferred, and leaden, tinned cast iron, or earthen vessels glazed with litharge, or red lead, totally rejected as injuring the cream and skimmed milk. The dishes are not to be scalded unless they contract some taint. New dishes, and those that have been scalded, should have some sour butter milk kept in them for twenty-four hours before the milk is put into them. The dishes to be placed on the shelves in the order the cows are milked, and which should always be the same, that the owner may estimate the value of each cow, and get rid of those that are unprofitable.

The cream is to be taken off at the end of six or twelve hours, according to the heat of the weather, and collected in a tub, having a spigot close to the bottom, that the milk that separates from the cream may be drawn off morning and evening. The cream of each milking is to be kept separate, and if in sufficient quantity also churned separately. The cream is kept in these tubs until it acquires such a degree of sourness that it will yield butter by a moderate degree of agitation; which will, in general, require at least three days in summer, and a week in winter. The cream being churned and strained from the butter milk is to have the remains of the butter milk carefully squeezed from it, with as little working of the butter as possible, and then moulded into the form used in the coun-

try. Butter should not be touched during its making by the hand; but worked with the wooden hands used by the cheese-mongers.

Such is the method which experiments show ought to be followed in making butter, but the dairymen of different counties follow several other modes by which they obtain butter of various qualities.

In the counties around London the fresh cream butter is made by letting the milk, in summer, remain in the pail until it is nearly cool before it is strained into the cream vats; but in winter time it is strained immediately, and a small quantity of boiling water added. In summer the milk does not remain in the vats more than twenty-four hours, and is skimmed either before sun rising or after sunset: in winter it remains thirty-six or forty-eight hours. The cream is kept in a deep pan, and if a churning does not take place every other day it is shifted daily into clean pans, and kept in a very cool place. A churning should take place, at least twice a week in hot weather, and the churn remain during the whole time a foot deep in water. If the butter does not come after considerable agitation, a spoonful of vinegar is added to each gallon of cream. In winter time a little juice of carrots is sometimes added to the cream when put into the churn, to give it the colour of May or Spring butter. The butter is immediately washed in many different waters till it is perfectly cleansed from the milk, and then made up into rolls, called Epping butter or skittles.

In the west of England scalded cream butter is made by letting the milk remain in shallow earthen pans for twelve hours in summer, and twenty-four hours in winter; the pans are then placed in stoves, made on purpose, and filled with hot embers, where they remain till bubbles arise and the cream changes its colour, when it is removed to the dairy, left for twelve hours more, and then skimmed from the milk, and put immediately into the churn. Some scald the milk over the fire, but then the smoke is apt to affect it. Others put the cream into a wooden tub and work it into butter by the hand. This butter is usually dished in half pounds for sale, the inside of the dish being rubbed with salt.

In Lancashire and some parts of Cheshire the milk of each cow is divided, the first drawn being set apart from the afterings, or second drawing of the udder. The first drawn being skimmed, the skimmed milk is used in the family, and the cream added to the whole of the afterings, which are not skimmed, but when sufficiently soured the milk and cream are churned together. To accelerate the souring the milk house

has a fire kept in it, and the wooden milk dishes are not scalded, unless they contract some taint; new dishes and those which have been scalded are rinsed out with butter milk.

Butter is made on the breeding farms in the Highlands of Scotland, by letting the calves suck out half of their mother's milk, then driving them away and milking off the remainder. This butter is extremely rich, but as the farmers cannot be fashed by straining the milk, the cows' hairs are usually mixed in such large quantities with it, that it is not saleable.

When cows are fed upon turnips, the disagreeable taste of the turnip is taken off, both from the milk and butter made from it, by adding a tea-cupful of a solution of saltpetre into every eight gallons of milk as it comes from the cow.

The milk from which the cream has been skimmed, may either be made into cheese, and the whey will afterwards do for store pigs; or, if the dairy is in the neighbourhood of a town where such articles can be sold, the skimmed milk may be made into sour cream and wigg.

In this case the skimmed milk is put over night into an open headed tub or small churn, with a spigot at the bottom, this is then put into a larger vessel, and hot water poured into the space between them. In the morning, the vessel of milk is taken out, and the spigot being drawn, a thin part, called whig, runs out, and as soon as the thick part begins to run, the spigot is closed, and the thick part is poured into another vessel. When the operation succeeds properly, the thick part is nearly half the milk, and seems to be as rich as real cream, from which it can only be distinguished by its sourness. It is eaten in Scotland with sugar, esteemed as a great delicacy, and usually sells at twice the price of fresh milk. Practice, however, is required to make this article properly. It seems totally unknown in London and its neighbourhood.

In large dairies the labour of skimming the cream is endeavoured to be obviated by churning the milk entire. In warm weather the milk is fit for churning in 48 hours, and it is usual to add a little cold water near the end of the churning to promote the separation of the butter. In cold weather the milk is kept a day or two longer before it is churned, and boiling water is added to it when in the churn. In very cold weather the milk must be kept in a warm place to promote the coagulation, as the sooner this is accomplished both the butter and butter milk are the better, for when milk is long kept it contracts a disagreeable rancid taste.

Milk butter is not so rich as cream butter, but will keep much longer sweet: when churned, as is most usual in large dairies, in a barrel churn, it is still poorer, but its quantity is increased sometimes double, as the milk is left quite exhausted. It is in this manner that the dairies about Epping make their butter at present; so that the butter that was the best is now the worst in the London market. The butter milk is used for feeding store pigs.

Where cheese is made from unskimmed milk, butter is sometimes made from the whey, but this whey butter only serves for present use in the house, as it will not keep more than a couple of days; and is indeed not worth making, as the whey fattens pigs very fast and makes delicate pork, but no good bacon can be made from pigs thus fattened.

For the purpose of preserving butter it is usually salted, and packed in barrels. The proportion of salt is generally an ounce to a pound of butter. As the salt butter is brought to London from distant counties where labour is cheap, it is generally cream butter, and therefore, the London buttermen of-

ten wash the salt out of it and sell it for Epping butter, since the dairies round London have got into the habit of churning from the milk. If a private family opens a barrel of salt butter and consumes it but slowly, the butter should be covered with strong brine, to prevent the air from turning it rancid.

Thirty pounds of Lancashire butter, well salted with a double allowance of salt, were put into two mugs, and each covered with a pint and a half of brine. After keeping in a cool cellar for 13 months, they were examined, and found to be perfectly good, two years and seven weeks having elapsed, the mugs were broken by an accident, and the butter being found to be perfectly good, the salt was washed out, and the butter sold for fresh butter in the Liverpool market.

A far superior kind of salted butter, called Udney butter, is made by using for the seasoning a mixture of two pounds of salt, one pound of saltpetre, and one pound of sugar beat well together. This butter does not taste well until it has stood at least a fortnight after being cured, but it then tastes rich, marrowy, and but slightly salted.

For exportation to hot climates, butter ought to be clarified before it is salted. For this purpose it is put into a lipped vessel, and placed in a vessel of water which is to be gradually heated until the butter is melted. It is to be kept melted for some time to allow its mucilaginous particles to settle; the clear melted butter is then to be poured off from the dregs, and when sufficiently cooled is to be salted. This clarified butter is paler than the fresh, and it acquires nearly the consistence of tallow.

Butter is sometimes preserved with honey as a delicacy. It is first clarified, and being poured off from the dregs, an ounce of firm honey is added to each pound of butter well mixed with it. This mixture will keep for years without becoming rank.

Cheese.

Cheese is the curd formed in milk when coagulated by the addition of certain substances, pressed and dried for use.

There is scarcely any article in which a greater variety of appearance and taste exists; the inhabitants of almost every valley on the face of the globe make a different kind of cheese.

Milk is usually manufactured into cheese when the farms are too far distant from a large town for the milk to be sold fresh, or even as butter, it being the least profitable manner of using it.

Cheese from new milk fresh from the cow. To this belongs the best making, or one meal Gloucester cheese, of which two sorts are made, thin or single cheeses, about 8 to the cwt, and thick or double, about 4 to the cwt. The single cheese is mostly made from April to November, the double only in May, June, and the beginning of July. When, however, the cows are well fed, good cheese may be made in the winter; but, in

general, the milk in the winter is not rich enough, and even the cheeses made late in the summer do not acquire sufficient firmness to be marketable in the spring.

The liquid employed throughout England for coagulating milk is called *rennet*, *runnet*, or *steep*. A calf's stomach bag, or maw, is washed clean, and salted thoroughly, inside and out. In two or three days, the salt left on it having run, it is hung to drain for two or three days, re-salted, put into a jar, and covered with paper, pricked with pin holes. It may be used in a few days, but is best kept for 12 months. When prepared for use, a handful of sweetbriar leaves, of dog-rose leaves, and of bramble leaves, as also three or four handfuls of salt, are boiled in a gallon of water for a quarter of an hour; and when quite cold the salted maw is added, as also a lemon stuck round with a quarter of an ounce of cloves. The salt must be in sufficient quantity that some may always remain at bottom; and the steep must be scummed as often as is necessary.

The milk warm from the cow is first coloured, by rubbing down on a stone some annatto, about 1 ounce for each expected cwt. of cheese, and mixing it with the milk. The rennet is then added, about one-third of a pint to 50 gallons of milk. As soon as the milk is curdled, the whey is strained off, the curd broken small, put into a vat, and pressed gently for two hours, then turned, pressed again for six or eight hours, again turned, rubbed on both sides with salt, pressed again for twelve or fourteen hours, and finally dried on a board, being turned every day. In large cheeses, the sides are pierced with iron skewers to allow the whey to escape during the pressure, which is very moderate, upon a medium only 1 cwt. and a $\frac{1}{2}$ dead weight.

Gloucestershire has hitherto been the principal seat of this manufacture; but North Wiltshire begins to take the lead. Cheddar cheese is of this kind, and esteemed the choicest sort, but the quantity made is very small. The Gruyere cheese of Switzerland is also of a similar kind; like Cheddar cheese, it is full of eyes, filled with rich limpid oil, which is not rancid; in flavour, this cheese is decidedly superior to any of the English species; the rennet is probably made with an infusion of aromatic and sweet herbs, instead of the leaves used in England.

For lyings-in, christenings, and other festivals, fancy cheeses are made, such as truckle cheeses or loaves, brick bats, hares, rabbits, dolphins, and the like; these are mostly made in Wiltshire. Green cheese is made by steeping over night in milk, some sage, with half as much marigold leaves, and a little parsley, and then mixing the curd of this milk, with the curd

of white or ordinary milk: this is also chiefly made in Wiltshire.

Cheese made from the milk of two or more milkings mixed together. The Cheshire cheese is of this kind; in general only two meals or milkings are put together, but sometimes, when the milk is scarce, three, four, or even five meals. The cold milk, being creamed, one-third or one-half is made scalding hot, and one-half is then added to the remainder of the cold milk, which has, in the meanwhile, been coloured by a piece of annatto, tied up in a linen rag, soaked all night in warm water, and then well rubbed into the milk, until the bag has given out all its colour. The other half of the scalded milk is mixed with the cream, and both the parcels added to the milk warm from the cow; this melting of the cream, as it is called, is thought to be the best method of uniting two or more meals of milk.

Rennet, made with plain brine only, in which the maws have been soaked for 24 hours, is immediately added, and when the curd has come, it is cut into pieces by a knife, the whey skimmed off, the curd broken smaller by the hand, and some salt mixed with it. Being vatted, it is pressed for about an hour, taken out, and left to stand in hot whey or water for an hour or two to harden its skin. The cheeseling is again pressed for a couple of days, but it is often taken out, skewered, and turned. The cheese is then either left in brine for several days, turning it once a day, at least, or it is turned at least twice a day for three days, and the upper surface covered with salt. After this, salt is rubbed upon it daily for eight or ten days, and it is then washed and dried. A cheese of 60 lbs. takes in all usually 3 lbs. of salt. When dried, the cheeses are smeared every day for a fortnight with fresh butter, which is well rubbed in; and as long as they are kept they are turned every day, and butter rubbed in three times a week in summer, and twice in winter. The consumption of this cheese diminishes very rapidly.

The Dunlop cheese of Scotland is also made from the evening meal of milk, warmed, mixed with the morning meal, and the rennet added immediately; no colouring is used. The whey as it gathers is laded off, the curd drained, and even pressed with a light weight. It is then cut up by a knife with three or four blades, salted, mixed by the hand, and pressed with a heavy stone of 10 or 20 cwt. being frequently taken out and examined. When all the whey is pressed, the cheese is taken out, turned, and rubbed frequently with a coarse cloth. The usual size is from 20 to 60 lbs. in weight.

In Ross-shire some private persons bury these cheeses separately in the shore below high water mark, to make them become blue, moist, and rich tasted.

Cheese made by adding cream to new milk, or cream cheese. Of this kind is Stilton cheese, the cream of the night's milk is added to the morning's milk, along with the rennet. The curd is not broken, but put into a sieve to drain, and very gently pressed; when the cheese is sufficiently firm, it is put into a wooden ring, and kept on a dry board. These cheeses are mostly made in Leicestershire, and weigh from 6 to 12 lbs. They are not saleable until decayed, blue and moist, which requires about two years' keeping. A little wine is sometimes added to the curd to bring forward the blueness earlier: others place the cheeses in buckets, and cover them with horse dung.

A thicker sort of this cheese is called Cottenham cheese.

The Lincolnshire cream cheese, called in London new cheese, is made in the same manner, but is little more than an inch thick. It is pressed with a two pound weight, and sold when only a few days old, to eat with radishes or salad.

York cream cheese is thus made; the curd when turned out of the sieve is cut into a square cake or tile, placed on rushes, covered with them, and pressed with a half pound weight. It can only be kept in a cool place, and for a few days: the whey left in the curd becomes acescent, and this acidity is agreeable to some palates.

Cheese made from new milk, mixed with skimmed milk. The half covered milk Gloucester cheese is of this sort; they are usually marked with a heart, to distinguish them from the best covered milk cheeses, and are often called Warwickshire cheese: it sells about 10s. by the cwt. less than the Gloucestershire.

Cheese made of skimmed milk only. This cheese is only made in those districts where butter is the chief object of the dairyman; and the milk is used after it has been skimmed three or four times; as in Essex and Suffolk. The English cheese of this kind has seldom a good flavour; but although it is generally nearly as hard as horn, it is much easier of digestion than some of the soft cheeses. The Dutch round cheeses which belong to this class are of a fine flavour; and the Parmesan cheese of Italy, is, by many, esteemed to have the finest flavour of any cheese, not even excepting Gruyere.

Parmesan cheese is made of two meals of skimmed, the evening's meal having stood about 18 hours, and the morning's about six hours. The mixed milk is heated in a copper boiler to 82 deg. Fahr. a lump of rennet, the size of a walnut, for 66 gal-

lons, is tied up in a cloth, and worked through it into the warm milk, which is then turned from the fire, and left for an hour to coagulate; after which the curd is stirred up for another hour, broken much smaller by a stick stuck all round with wires, and left to settle. Part of the whey is taken out, the boiler turned again over the fire, one-fourth of an ounce of saffron added to colour it, the milk made nearly to boil, keeping it well stirred, and occasionally examining some of the curd between the finger and thumb. When the curd feels sufficiently firm, the boiler is removed from the fire, three-fourths of the whey ladled out, and three or four gallons of water dashed against the boiler to cool it. A cloth is slid under the curd, and it is placed in a tub to drain; it is then put into a hoop and pressed with half a cwt. for an hour. The cloth is then taken away, the cheese placed again in the hoop for two days; after which the two cheeses are placed one on another, changing them every other day, for a month in summer, and six weeks in winter; during which period they are sprinkled over with salt, at each time of turning them. The cheeses are then scraped clean, turned every day, and rubbed frequently with linseed oil to keep off insects: they are never sold until six months old.

In some imitations of Parmesan cheese, ewes' or goats' milk is added to that of the cow; or the cheese, as at Roquefort, is made entirely of ewes' milk.

Cheese made of whey and butter milk. After the curd of Parmesan cheese is removed from the boiler, all the whey is added to the butter milk of the morning's meal, which has been churned in the mean while, an acid added to coagulate it, and thus a cheese called maschopino is made.

The fatness of cheese cannot be ascertained by its appearance, but by toasting it, as some cheeses, apparently fat, dry up by heat, while other dry and hard cheese when toasted becomes fat.

A cow ought to produce her own weight and value in cheese by the year.

Four hundred and fifty gallons of cows' milk ought to produce four hundred and thirty pounds of cheese, ewes' milk would produce a greater quantity.

The milder sort of these cheeses are used for food, as the Gloucester and Warwickshire cheese; but the highly salted kind, as Cheshire cheese, are mostly used in small quantities to flavour bread, and other food. The power of promoting digestion attributed to cheese, does not belong to any of these cheeses, but to the ammoniacal cheese, which is totally different.

Ammoniacal Cheese.

The fromage de Brie may be taken as an example of the foreign cheeses, in which the cheesy matter is so totally altered that it is no longer acid or neutral, but is become putrescent and ammoniacal, so as to emit ammoniacal gas, when rubbed with salt of tartar.

The milk warm from the cow is strained, a very small portion of rennet is added to it, and it is left for twenty-four hours. The curd is put into a hoop and drained for several days in a cellar; it is then taken out of the hoop and exposed to the open air, whose temperature is about 59 or 60 deg. Fahr., and is turned every other day, and sprinkled with salt. When dry it is returned to the cellar, placed upon hay, and occasionally turned until it has become perfectly mellow, and as it were putrid.

The cheeses of this kind are generally made very small; sometimes only a few ounces in weight, so that half a cheese is the ordinary service for a single person. Some are made like small brickbats, others globular like wash balls. Only the middle is eaten.

The digestive qualities usually attributed to cheese by physicians, probably belongs only to this kind.

DISTILLED WATERS.

Some of these are intended for medical purposes, mostly as vehicles, others for perfume. In respect to medicines, no great care is usually judged necessary, the herb just as collected, without any preparation of decayed parts, or accidental mixture of dirt or other substances, is added to the water, distilled in a short necked wide still as quickly as possible, and 2 drams of spirit of wine, or even more, added to each pint. Many do not even take this trouble, but rub a drop or two of the oil, with a little magnesia, and add it to common water, or dilute the oil with ten times as much spirit of wine, and add, when it is wanted, a few drops of this essence to the water or other vehicle.

But for perfumes, as rose water, elder flower water, &c. more care is requisite, as the buyers must be pleased with their smell and appearance; hence the herb, &c. must be carefully picked, and the water as carefully distilled in a high necked still, in order that no part of the infusion may be thrown over with the distilled water, as this would render them liable to become motley in a short time: if a superior article is required, the wa-

ters must be re-distilled by a gentle heat. Waters which have acquired a burnt smell in the stilling lose it by freezing.

These waters must also be kept in a cool place, covered only with paper, pricked with pin holes, for four months, to get rid of the herbaceous smell of fresh distilled waters. Distilled waters may be prevented from turning sour by adding a little calcined magnesia to them; and those which have begun to be spoiled may be recovered by adding to each pint, a grain of each, borax and alum. A drop of muriate of gold added to these waters shows whether they contain any oil, by forming, in that case, a fine metallic film on their surface.

These waters are now more commonly distilled from the essential oils of the plants, than from the plants themselves. The price of the oil, combined with that which can be procured for the water, determining the quantity to be added.

The distilled waters usually made in England are rose water, mostly from the Barbary oil of the evergreen rose, and elder flower water, from the flowers themselves.

The distilled water of silver weed, or wild tansey, is used by the French in dressing gauze, and this is the only instance of a distilled water being used in the arts.

INFUSIONS, DECOCTIONS, AND EXTRACTS.

These are solutions of the proximate principles of vegetables and animals in water; either liquid or boiled down to a solid consistence.

Tea.

Although the consumption of Chinese tea is greater in England than in any other country, yet no where is it made so bad, or on worse principles.

To have good tea the whole quantity of boiling water intended to be used should be, as is the case in all infusions, poured at once on the leaves, previously bruised, left to stand until sufficiently impregnated, then strained off, and the auxiliaries, milk, cream and sugar, added.

A still better method to preserve the flavour of the tea is, to pour the requisite quantity of cold water upon the bruised leaves, and put the vessel into a pan of water boiling on, or beside the fire, until the tea is sufficiently heated to be poured off and drank, observing that if much milk, or the like is added, the tea must be made so much the hotter, that they may not cool it too much. This is the usual method in China.

A variety of British plants have been proposed as substitutes for Chinese tea, but they do not possess the quickly diffusible

stimulus of the real tea. Besides, they are used too fresh, the Chinese keep their tea two years before they use it; and from their cheapness are employed in too great proportion to the water.

The usual consumption of tea for a man and his wife in England is about a quarter of a pound of tea, and a pound of white sugar weekly; this will give half a quarter of an ounce of tea, and half an ounce of sugar for each person at each meal.

Coffee.

This is more drank on the Continent than in England: indeed, that drank here is a mere slop compared with the foreign, which is, however, of very different strengths, even so far as to be drank unstrained, and of sufficient thickness for a spoon to stand upright in it for a short time.

The usual allowance for coffee in England is about one-fourth of an ounce for each person; the Dutch and Germans allow about three times as much. It was formerly boiled up several times, whole black mustard seed added to increase its stimulant quality, and then clarified with an egg. At present it is a mere infusion, the hot water being only run through it, and the infusion heated again.

Late experiments have shown that the best way of making coffee, is to put the ground coffee into a wide-mouthed bottle over night, and pour rather more than half a pint of water upon each ounce and a half, to cork the bottle, in the morning to loosen the cork, put the bottle into a pan of water, and bring the water to a boiling heat; the coffee is then to be poured off clear, and the latter portion strained; that which is not drank immediately is kept closely stopped, and heated as it is wanted.

Rye, roasted with a little butter, is much used in England as coffee, by the name of economical breakfast powder. On the Continent, about one-third of succory root roasted is added, to diminish the expense of drinking pure coffee.

A number of infusions and decoctions are made by the apothecaries, but they cannot be considered as manufactured articles; neither can the infusions of litmus, and the like, which are used as tests.

Cake Glue.

The materials from which glue is made are the shavings cut off from the skins in currying the various kinds of leather, the leather packages of indigo, aloes, and other commodities; also hide ropes, ears and feet of hides preparing for tanning. All of these are soaked for a fortnight or three weeks in pits of lime

and water, fresh lime being added every week; after which they are rinsed in water to get rid of the lime, and spread on a pavement till the superfluous water is dried away.

These materials are then boiled in water until they are entirely dissolved, and that the liquor dropped upon a cold stone becomes solid, when it is run off into an iron pot warmed by heating some water in it, and there kept quite hot for four hours to settle; after which it is run off into the moulds, which are shallow wooden boxes, the sides being only the intended thickness of the cake in height. The liquid glue is ladled into these boxes through a horse-hair sieve. After being in these boxes and a cool place for eighteen hours, the glue is sufficiently firm for drying on the net. A wetted knife is run round the edge of the box to loosen the cake, and the box turned over and let fall upon a table to separate the mass of soft glue, which is then cut by a copper wire stretched by a frame in square cakes, and these are dexterously taken up by a knife and placed on nets stretched in a wooden frame, and these frames are supported by stages to allow the glue to dry.

In hot weather, the glue dries too quick, and is apt to crack; in cold weather it freezes; moist weather not only retards the drying, but makes the cakes stick to the nets; and if it is also hot, even to run through them; so that the cakes are sometimes obliged to be dissolved and moulded again.

When the cakes are sufficiently dry, which in moist weather frequently requires the use of a stove, they are glazed, by being dipped, one by one, in boiling water, and then rubbing them with a brush; after which, if the weather is not very fine, they are placed on frames in a stove, until sufficiently dry to be packed up for sale.

The remains of the material left in the boiler have a little water added to them, and are then taken out and pressed. What liquor is obtained from them is added to the water in the boiler, and used in the next operation.

Attempts have been made to improve the manufacture of cake glue by putting in a larger quantity of materials in proportion to the water, and drawing off the liquid as soon as it is sufficiently charged to set when cooled: to add hot water to the materials still in the boiler, and again draw this off when sufficiently charged; and to add a third time fresh water to the remains. By thus dividing the products, the first drawing off, which has not felt much of the fire, affords a light-coloured clear glue, the second a dark-coloured glue, rather opaque, and the third a reddish muddy glue. This method has been obliged to be given up, because workmen prefer dark-coloured to transparent glue.

When cake glue is to be used it is broken to pieces and soaked for a night in its own weight of water.

Flemish or Dutch Glue.

The material is the same as for English glue; but they are better rinsed in several waters, and even left to soak some time, that they may require less boiling. The boiler is run off twice, the liquid not being so much boiled down as usual, and the cakes are made very thin, that they may appear transparent.

French Glue.

The boiling of the materials is continued a long time with a small fire, and the liquid carefully scummed. When the materials are dissolved, the liquid is made to boil, and then drawn off into the lower caldron, about two grains of alum to the pint is added to clear it, and after an hour or two it is moulded. This glue is transparent and very brittle.

Hat-makers' Glue.

The materials from which this glue is made, are the tendons and small bones of the legs of oxen and horses; as much muscle is left with the tendons, the glue remains soft, and absorbs the moisture of the air. It is brown and opaque. The hat makers prefer it as not rendering the felt brittle.

Size.

The materials for this kind of soft glue are the skins of rabbits, from which the hair has been taken for making hats, old gloves, the trimmings of parchment, as also parchment records or manuscripts, obtained from the porters of the register offices or public libraries.

The boiling is made with a small fire that the liquid may not become coloured, and there is added about twice as much water as in making the cake glue; when sufficiently boiled it is drawn off into barrels.

Size is also made from the same materials as cake glue, only the first of the boiling being taken.

The single size is very soft, but for some purposes double size, of a firmer consistence, is made.

French Bone Glue, Gelatine Brut,

Is made from the skulls of oxen, the spongy insides of ox horns and the ribs; by washing them, soaking them in an equal

weight of weak muriatic acid, at 6 deg. Baumé in the winter, and 5, or only 4 in summer, for about ten days; pouring off the acid, soaking them afresh in acid at only 1 deg. Baumé for a day and night, steeping them in water for some hours, renewing it five or six times until all the acid is washed out, and finally steeping them in a very weak solution of subcarbonate of soda. 100 lbs. of bones yield about 25 lbs. or 27 lbs. of gelatine brut: which is used for making carpenters' glue, as the fat in the bones gives it a bad taste, and renders it unfit for soup.

Portable Soup.

Break the bones of a leg or shin of beef, put it into a digester that will merely hold it, cover with cold water, boil it gently for eight or ten hours, strain, let it cool, take off the fat, pour into a shallow stew-pan, add whole black pepper a quarter of an ounce, boil away to about a quart, pour it into a smaller stew-pan, and simmer gently till it is reduced to the thickness of a syrup, then either pour it into small upright jelly pots, with covers, and when cold paste the joints over with paper; or pour it out upon flat dishes, to lie about a quarter of an inch deep; when set, divide it in pieces and dry them. A shin of beef of 9 lbs. produced 9 oz. of portable soup, and 2 lbs. $\frac{1}{2}$ of meat fit for potting: no other part yields so much.

French Portable Soup, Gelatine Fin,

Is made from the skulls, blade bones, and shank bones of sheep, the ends being cut off, and the bones cut down the middle to remove the fat, steeping them in muriatic acid, as the gelatine brut of ox bones, then in boiling water for a few minutes, wiping them carefully, drying them, shaking them together in a bag to remove the internal pellicle; cutting them across, or into dice to disguise them, and finally dipping them in a hot solution of gelatine to varnish them. Used to make soup, keeps better than the cakes of portable soup: and when less carefully prepared it is used also to make carpenters' glue for fine work. The muriatic acid obtained by distilling salt with oil of vitriol in iron cylinders is less fit for this purpose than that of the manufacturers of subcarbonate of soda, as being apt to give the gelatine a bad taste.

FERMENTED LIQUORS.

All fruits consist of the following principles: water, sugar, a peculiar combination of sugar and extract, called the sweet

principle by the French, supertartrate of potash, malate of potash, and malic acid, superoxalate of potash, extractive matter analogous to mucilage, vegetable gelatina, tannin, a principle of flavour, and a colouring principle.

The essential ones to the making of wine are the tartaric acid, sugar, or the sweet principle, extract, and water; and those which are useful, without being indispensable, are flavour, tannin or astringency, and colour.

Tartaric acid, or its combinations, is especially indispensable: and hence it is that the grape, which contains it in large quantity, produces wine; when the apple, and other fruits which contain the malic acid, produce cider.

Where malic acid is also present, the quality of the wine is bad. Sugar must be considered the fundamental element, and as that from which the alcohol is chiefly derived. Thus the most saccharine grapes produce the strongest wine.

The chemical nature of the extractive matter is not known; but it is supposed to contain azote, as this is the produce of fermentation. Yeast, or leaven, contains the extractive principle in great abundance, and hence its power in inducing fermentation in a solution of pure sugar. All vegetables contain it; and it is most abundant in those juices which gelatinate in boiling. It is found in the grape, and it is thus the natural leaven of wine, whether existing in a separate state or united to sugar in the form of the sweet principle. Water is a much more essential ingredient than would at first be suspected. If over abundant, it is difficult to prevent the produce from running to the acetous stage; hence weak wines become sour. If deficient, it is difficult to establish the fermentation; and hence sweet wines. Thus, also, sweet wines are ensured by drying the grapes, or evaporating their juice, both common practices in the wine countries. Colour must be looked on in the light of an ornament, and is found in the husk of the grape. So is the tannin principle, which occasions astringency in port wine. Of the principle of flavour chemistry knows nothing; it seems often the produce of fermentation, as in claret and Burgundy wines: in those of Frontignan and Muscat, it is the natural flavour of the fruit.

In fermentation, the superfluous extract or leaven is separated in two forms, that of yeast and lees; and these will excite that process in fresh solutions of sugar, or renew it, or continue it, in the mixture whence it was separated; whence racking and fining. There is, however, one important difference between the natural or original, and this artificial or secondary leaven. The latter is soluble in hot water, and not in

cold; and hence it is separated in fermentation. By restoring this separated matter to wine in the course of fabrication, the fermenting process is prolonged, or the wine rendered drier; by skimming, and fining, and racking, the process is checked: and hence the application of these practices to sweet wines. The *rolling* of wine, or returning on its lees to *feed*, is hence understood; and hence also the improvement which certain wines experience in long voyages. But the same principle and process which improves Madeira destroys Burgundy, and the reason must now be obvious. The theory of racking, fining, and sulphuring, is hence also apparent; and, of the sulphurous acid, it has a property to combine with the leaven, and form an insoluble separable compound. It is thus that it checks fermentation. Hence, also, it is that sweet wines do not turn sour; their leaven has been expended. Thus also we may see that the process of fermentation is not an unmanageable and a precarious one; but that the essential ingredients are in our power, and that we can modify them to the desired result.

If it has been stopped prematurely, it may be renewed by fresh leaven; if in excess, it may be checked or suspended. And thus it is too, that dry wines, and fined wines, and wines in bottles, are durable, when they would perish in the cask.

The acid was shown to be also essential to the produce of wine. Mere extract, or leaven, and sugar, produce beer, not wine. Tartaric acid cannot well be in excess in that compound in which it exists, viz. the supertartrate of potash; because it is a salt of difficult solution, and the superfluity is precipitated; hence the tartar of wine casks; hence, also, the crystals which are seen, in cold weather, to float in Madeira wine. A part of it is converted into malic acid; hence the peculiar properties of some wines; hence also the practice of liming the vats, or of sprinkling the grapes with lime in the manufacture of Sherry wines; whence they acquire that peculiar dry and hard taste which distinguishes them from the wines of Madeira.

As the tartaric salt adds to the fermenting power of the fluid, hence we explain the facility with which the juice of green grapes runs into fermentation when compared with ripe ones; the immature fruit containing a much larger proportion of this salt than the mature. Thus also those wines continue to ferment longer, or to retain the power of fermenting; and hence the vivacity of Champagne wines, the most effervescent kinds of which are made from half ripened fruit.

The temperature of 54 deg. Fahrenheit, is considered the most favourable to this process. Hence, also, it is that wines which have ceased to ferment, re-commence in spring; and

hence, one of the processes essential to the manufacture of Champagne wines; namely, that of watching the spring fermentation, and bottling the wines in this stage.

The volume of the fermenting fluid has a considerable effect on the process; a few days are sufficient to complete it when the quantity is large. When small, it is difficult to establish, and tedious in the progress, and the results are also different.

That substance, which exists in yeast, has also been found in the disengaged gas, partly, it is said, in the form of ammonia; and hence, possibly a nauseous ammoniacal taste, well known in bad wines, and very remarkable in those of the Cape of Good Hope.

The colour of wines is also produced during the fermentation; the red appears to be a substance analogous to resin, soluble in alcohol; and thus its production is accounted for. Hence, white wines may be made from red grapes, by excluding the husks; hence also, red wines are often astringent; because the tannin also lies in the husk. Thus also, in Champagne wines, the red are generally inferior.

Thus, when all the necessary circumstances are present, the process goes on till the produce is pure wine, or a compound of alcohol, water, acid, colour, vegetable extract, and sugar. For although the two latter are said to be destroyed, there is almost always a minute portion of both remaining; the former rendered very sensibly, in some wines, by the skinny matter which they deposit on the sides of the bottles. In a similar manner, it happens, that a portion of sugar continues attached to the wine for a long time, though it is not always sensible except to a fine taste. Thus, it is perceptible in claret, and even in Madeira, which are among the driest of our wines. It is often very sensible in Port; and, when in excess, is commonly the mark of a bad wine.

It is the gradual conversion of this sugar, the chief operation that goes on in bottled wines, which is the cause of the change which these undergo. This process often requires many years for its completion; this is the case in the clarets of Chateau Margaux, and other Bordeaux wines; and the same process indeed takes place, to a greater or less degree, in Madeira and the other strong wines. In these cases, it is a cause of improvement; the wine becoming more perfect under this last tedious fermentation; in others, however, it is mischievous: and hence the destruction of many wines. Thus Champagne is destroyed, and often very quickly: thus Burgundy also is easily ruined; and thus, even our Port is not a very durable

wine, though the destruction is here accelerated by the intermixture of brandy used in this particular manufacture.

By the same considerations we can account for the benefit which Madeira wines receives in a hot climate, or in a hot cellar. The effect of the heat, and in the case of a sea voyage, united to the agitation, whose action was considered before, is that of accelerating the imperceptible fermentation, and thus ripening the wine sooner than would have happened, in a low temperature and at rest. It is a mistake to imagine, that this is peculiar to Madeira, or that it is the only wine which can be benefited by this treatment. It is the same for all the Spanish wines, for Sherry and for Port, and it is also true of the better and safer wines of France, of those of Hermitage and the Bordelais. Claret becomes drinkable in a much shorter time in a warm than in a cold cellar; and that is equally true of many more of these wines. But that which some will bear, others will not; and thus many of the wines of France, so far from admitting a high temperature, can scarcely be preserved even in a low one. As to Port, it is a useful piece of knowledge to be aware, that it may speedily be rendered aged by heat. And in this case it deposits its colour, and assumes the marks of old wine to the eye as well as to the palate. One year will thus do that for Port which might have required five or six; but the period of its entire duration is consequently shortened, as might be expected. The effect of heat is indeed such in this case as is suspected by few. In America it is a well known practice to boil Madeira, or to heat it to the boiling temperature, and the effect is that of rendering it good and old wine, when previously harsh and new. The same practice is applicable to Port. If newly bottled wine be exposed to the sun, it begins shortly to deposit, and improves in flavour; and even the rawest wine of this kind may, by heating it in hot water, be caused, in the course of a day, to assume the quality which it would not have had until after many years of keeping.

In Hock, it would seem as if every atom of sugar had vanished, and yet the durability of that wine appears to be endless. If that is not absolutely the case in Claret and Madeira, still these are very durable wines; the most so, after Hock, at least of the dry class. None of these, when of a good quality, ever run into the acetous fermentation.

When all the favourable circumstances above stated are present, the fermentation begins and passes through its regular stages till there is produced wine, perfect and dry, if the sugar has been thoroughly and accurately proportioned to the other ingredients; sweet, if it has been in excess; and acid, as in Hock, when this substance has been in undue proportion to the other ingredients. The unfavourable circumstances must be sought in the temperature, or in the quality of the fluid. The juice of the grape rarely labours under any defect but the want of sugar, arising from a bad variety of this fruit, from a bad season, or from imperfect ripening. In the latter case, however, there may be added to defect of sugar or excess of water, an excess of acid and of extractive matter.

In the wine countries the defect of sugar is remedied by different expedients. In some, sugar or honey is added to the

juice, or must; in others, a portion of the juice is evaporated and added to the rest; and sometimes, all the juice is boiled before it is submitted to fermentation.

To gain the same ends, it is a practice in many countries to dry the grapes partially, by suffering them to remain on the vine; but this is chiefly resorted to for sweet wines, as in the case of Cyprus, Tokay, Lipari, and others. The other expedient for increasing the proportion of sugar in the juice is by plaster of Paris, or gypsum, not an uncommon ingredient; and this effect, as well as that of absorbing and destroying superfluous acid, is also partially attained by the use of lime.

The management of the fermentation, supposing the fluid to be perfect, is regulated by the intended nature of the wine. If sweet wine is desired, not only must the proportion of the water be diminished by one or other of the means above mentioned, if necessary, but the proportion of extractive matter or leaven must be reduced, to prevent it from running to the ultimate stage, and producing a dry and strong wine. In this case, the yeast is separated as fast as it rises by mechanical means; as by fermenting in full casks in such a manner that it may be continuously ejected at the bung hole as fast as it is formed. Should the reverse be desired, or a dry wine be the manufacturer's object, the yeast is suffered to remain on the surface in the vat, that it may be continually returned into the liquor by the internal agitation, or else it is stirred, or rolled in a cask, or in the vat, so as to protract the fermentation. Lastly, if the wine is to be brisk, to retain carbonic acid, as in the wines of Champagne, not only must the proportions of water and leaven be increased, but the fermentation must be conducted in vessels partially closed, and these also must be fully closed before the fermentation is completed.

Wines may be divided into four classes: the sweet and strong; the dry and strong; the delicate and light, which are generally weak compared to the former; and the effervescent or brisk. Malmsey, Tokay, Frontignan, are examples of the first, and the second are peculiarly familiar to England. Hermitage holds an intermediate rank, as does claret, between these and the third class; of which the lighter Burgundy wines, the white wines of Greece, and those of the Rhine and the Moselle, may be considered pure examples; and, of the last, Champagne is almost the only one that deserves to be named.

If, therefore, the intention is to make either a strong sweet wine or a strong dry one, the fermentation is commenced in an open vat. But, in the former case, it is not suffered to remain there long, as it is in the latter. For the driest wines, or for those which are manufactured for distillation, the fermentation is allowed to expend itself in the vat, and the wine is not tunned till it is made; the completion of the process merely, or the final solar fermentation, being reserved for the cask. In the sweet wines, on the contrary, it is soon removed from the vat to the casks, that it may be more in the operator's power to suspend the process, and thus to prevent the annihilation, or total conversion, of the saccharine matter. In the third class again, in the highly flavoured wines, of which Burgundy may be selected as an example, the fluid is only suffered

to remain a few hours in the vat; from six perhaps to twenty, that period varying according to the state of the temperature, the particular quality of the juice as to goodness or strength, and the other views of the manufacturer. This is done to prevent the dissipation of the flavour, which would be injured, if not destroyed, by an open fermentation. The same practice is followed for the wines of Champagne, though there is here little flavour to preserve; the purpose being, in this case, to secure the power of checking the fermentation by pressure, so as to retain the wine in a low stage of this process, and thus to secure a supply of mixed, or combined carbonic acid, at the period of use or drinking.

If, after the wine is made and tunned, it were suffered to go on fermenting, it would, in many cases, be destroyed. This, it has already been seen, does not easily happen in the sweet wines, where a large portion of the saccharine matter remains unchanged, though even these are not absolutely exempt. Nor does it very easily happen in the stronger dry wines. Yet it does happen to all, and is almost inevitable in the light still wines, and in the brisk ones, whatever the strength or sweetness of the latter may be. Champagne would quickly become vapid, Burgundy would become stale and sour, and claret would become vinegar. For though the natural progress is supposed to be from the vinous to the acetous stage of fermentation, there are phenomena in practice which show us that we are yet imperfectly acquainted with the exact nature and varieties of fermentation. Champagne, for example, becomes mucilaginous and flat; while, though Burgundy becomes acid, it is scarcely possible to make it pass to the exact state of vinegar.

The processes of racking and mechanical separation just described, are all intended to separate this matter: and whenever the wine remains turbid, it is always in danger, because the fermentation may at any time be renewed. But often these operations are insufficient to disengage all the leaven or lees; as much of it not only continues mixed, so as to produce the turbid state, but the extractive matter itself, which has not been brought to this insoluble form, remains combined with the fluid.

The merely turbid state is remedied by the process called fining, which precipitates all the insoluble or disengaged lees and leaven that will neither subside nor rise; thus removing one part of the hazard, besides communicating that brightness and beauty which is demanded in all wines. That brightness, therefore, is more than a beauty, since, without it, there is no security,—at least in the finer and lighter wines. Various substances are used for this purpose, and the action of many of them is very obscure. The mechanical substances are sand and gypsum, both of which have the property of precipitating the insoluble matter; while the latter also absorbs water. Beechwood

chips are sometimes used for the same purpose; but the mode in which these act is not known. But the matters chiefly in use are chemical ones, gluten and albumen. Of the latter, eggs and milk are both used; but the former are preferred. Of gluten, isinglass alone is used; for, from some causes hitherto undiscovered, the gluten of terrestrial animals, or common glue, does not produce this effect to the same extent that it is obtained by the glue of fishes. It is also usual to adopt albumen for the white wines, and gluten for the red; as the former is found to precipitate much of the colour from these last. The proportion used is very small, an ounce of isinglass being sufficient for a hundred gallons. To these chemical matters we might have added starch, gum, rice, and blood, but they are very little used. The action of the albumen appears more mechanical than chemical; becoming coagulated, and then entangling the dust, if it may be so called, which is suspended in the fluid, in the same manner as it would purify muddy water. In the case of the gluten, however, a new chemical combination is formed with the tannin of the wine; and the produce is that well known substance resembling bird-lime, which is the basis of leather. Hence, also, fining diminishes the astringency of red wines.

Presuming that one of these substances has been introduced, the fluid is strongly agitated and suffered to repose till clear, when it is again racked into a fresh cask. It is found very important to select for this purpose dry cold weather, and, as is particularly remarked, north-east winds. From some mysterious cause, in close weather, and fogs, and southerly winds, the precipitated matters rise again, and defeat the objects of the operation. The other precautions are those of using a syphon instead of a cask, as affording greater security; or, what is now used in all the best French manufactories, blowing off. This is performed by a condensing engine, as in the drawing of porter, and thus access of air is prevented. This is very important where fine flavoured wines are concerned, as it is in brisk wines; because the carbonic acid which would thus be lost, carrying away also a portion of the alcohol or strength of the wine, is thus preserved. But the leaven held in solution cannot be separated in this manner; and for that purpose recourse is had to the process of sulphuring. The most common and the simplest practice in this case, is to fill the proposed cask into which the wine is to be racked, with sulphurous gas, by burning matches in it. The wine, being then introduced, becomes turbid, and, after the necessary time, it is found as before. Should the fermentation still be renewed or dreaded, this operation is repeated as often as it may be necessary. If, as in the case of some of the Bourdeaux wines, the quantity of leaven in the wine is so great, that it cannot be overcome in this manner, the combustion of the sulphur within the cask is repeated at intervals during the process of filling it. But it is also a practice in that country to impregnate with sulphurous acid a quantity of wine, and this mixed fluid, called *Muet*, is reserved for adding to those which may require it; by which means the efficacy of the operation is better ensured.

In the wine countries, it is also usual to cultivate particular grapes or wines, rough, or coloured, or astringent, or high flavoured, for the mere purpose of mixing with others; so far is this art from being so simple as is commonly imagined. In many also it is a practice to import the wines of one country to mix

with those of another, and thus to suit the taste of purchasers, or obtain other ends. This practice is pursued even by the importers into Britain; and, as we need not say, opens a door to endless frauds, while it may also be innocent. Thus, in this country, as well as in Portugal, the wines of Spain, Alicant, Barcelona, and so forth, are mixed with Port wines: as are the cheaper clarets of the south of France, and some other of the strong flavoured wines of that country. In a similar manner, the wines of Fayal and the Canaries are manufactured into Madeira, as are those of Sicily; and thus, too, Sherry is largely compounded out of many of the wines of Spain and Portugal, and of the Islands of the African coast.

But the most extensive operations of this nature are carried on at Bordeaux, with the wines which we call claret, not one-thousandth part of which are of a good quality, or unmixed in some way, and the one-half of some of which, perhaps, are not French, but Spanish wine.

The French wines of which we have been speaking, will not endure to be rendered stronger by means of brandy. The property of this substance, thus mixed, is to decompose the wine in process of time; causing the extractive matter or mucilage to be deposited, as well as the colour, as is daily seen in Port wines, and thus diminishing their powers of duration. At the same time, it destroys their lightness and flavour; that peculiar indefinable delicacy well known to drinkers of good wine, but quite imperceptible to British drinkers of Port. In a certain sense, we may consider that it is only the bad wines which will bear this medicine; those which have no flavour of their own, and whose whole merit already is their strength. What sort of a compound is made of a weak wine with brandy ought to be known to those who drink what is called Lisbon wine. But a depraved taste has rendered it necessary to our nation; and thus it is largely used, even in those wines of Portugal and Spain, of which the chief fault is that of being too strong already.

Many wines have so little flavour, naturally, that they can scarcely be considered to possess any.

Wines so highly perfumed by nature as Hermitage and Burgundy, are rare; indeed, these are almost the only examples; and, after them, we may consider the finest clarets, and then the finest of the Rhine wines.

Constantia has rather a taste than a flavour; and what the ordinary sweet Spanish wines possess is rather bad than good; though, like the taste of sherry, and porter, and olives, they may become agreeable by habit.

The flavour of Madeira is nothing; but that which we know is given by means of bitter almonds, and, we believe, of sweet almonds also; and the same practice is followed for the wines of Saint Lucar. The *borrachio* taste in wine is for the most part that of the tar with which the seams of the skins are secured. In sherry the flavour seems produced by the destruction of the acid, the consequence of the lime used, and possibly by some

other action of that substance on the fruit. One of the most common ingredients used for flavouring wines is oak chips; and from this the wretched Lisbon wines acquire the little taste they have. Iris root is also a common ingredient; and the high flavoured wine of Johannesburg is imitated by a proportion of rose water. The iris root gives a very agreeable flavour, and is used in France; and there, also, it is the custom to use raspberries and other highly perfumed fruits. A very agreeable flavour is also said to be produced by wormwood. The flowers of the vine itself are also used for the same purpose, their smell much resembling that of our mignonette.

The colouring of wine is also part of the business of the maker; because colour is, in a good measure, a matter of fashion and fancy. Some grapes contain naturally very little colour, while that of the claret vine, and many of the grapes of Spain, are highly charged with the colouring principle. We already explained that the colour was contained exclusively in the husk. These latter vines are often, therefore, selected and reserved for this particular purpose; and it is also a practice to use the dyeing woods, logwood and Brazil wood, for obtaining the same end. The elder-berry, which is full of colour, is also resorted to; and in Portugal it used to be extensively cultivated for the purpose of dyeing Port wine. When white wines are thought too pale for the market, they are coloured browner by means of the well-known ingredient, burnt sugar; and the chips of oak also produce the same effect. By some means also iron finds its way into some of the French wines, and thus, on exposure to air, they become black. This unpleasant effect is not unusual in the sweet wines from the south of France.

Briskness of wines relates almost exclusively to the wines of Champagne, and it is one that may err in excess or defect. It is already apparent, that it is the produce of an unfinished fermentation, and, therefore, a due degree of it must depend mainly on the proper management of this process. It is secured by bottling at the proper season, March, and before the fermentation is exhausted; and, if in danger of excess, it is restrained or diminished by racking, or decanting, and sulphuring. But it happens not unfrequently that it fails altogether; either from accident in the management, or a bad season; from faults in the fruit, or fermentation carried too far, or a weak wine exhausting itself unexpectedly. In this case the remedy is to introduce sugar, not only into the casks, but into the bottles.

The acidity, or the pricked taste of wines, is a fault which, perhaps, ought never to be corrected, as, in this case, the wine is generally spoiled.

For the acidity of wine from the commencement of the ace-

tous fermentation, there is no proper remedy. It may be checked if taken in time, as it would be prevented, by careful sulphuring.

To prevent it as far as possible, when commenced, a low temperature, and careful exclusion from the air, are necessary. But it must be remembered that air will find access, not mere through cork, but through sealing-wax, and, indeed, through a. rosins also; and thus there can be no complete security; the best being that of placing the bottles on their sides, so that the fluid itself becomes its own cork. The Italian practice of using oil is thus far safer; but it is balanced by its various inconveniences.

The spirit may be separated from wines by careful distillation, or, if the extractive matter be first got rid of by the addition of subacetate of lead and filtration, the spirit may be separated by adding very pure and dry subcarbonate of potash, when it will swim upon the liquor: the spirit constitutes from 12 to 25 per cent. of the proper wines, and from 2 to 8 per cent. of the malt liquors.

Two chemists have examined the quantity of alcohol to be obtained from the fermented liquors mostly in use: Newman and Brande. It appears from the comparison of their experiments, that the wines of the present day are much stronger than they were about 80 years ago, at least in England, probably owing to the addition of brandy. Two-bottle men now actually drink more alcohol than their six-bottle grandfathers.

Champagne Wines.

The attentions required in Champagne wines are perhaps the most minute, and the most complicated, and they therefore stand most in need of being detailed. Champagne is a late country, and it frequently happens that the frosts have arrived before the grapes are ripe. A very brisk wine is not easily secured from grapes absolutely ripe; and thus the half-ripened fruit of this district is brought into use. Yet the best of these wines, the finest class of Sillery, rarely seen in this country, is made from the ripened grapes. And hence it is, that the best of the Champagne wines are those which are least brisk or violent, and that great violence is a characteristic of the inferior kinds. When there is violence and sweetness both, we may easily conjecture what the wine is; and in those, as might be expected, there is no flavour.

The finest wine is thus produced here by a very light pressure of the grapes; in which case only the ripest give out their juice. It is held necessary to gather them when the morning dew is off, to prevent water being added to the juice. The next

pressure, and the least ripe grapes, are reserved for the inferior classes. When the juice is poured into the vat, it remains one night only, the seeds being carefully separated. In all cases, also, the greatest care is taken to separate damaged grapes or rotten ones. If the Champagne is to be red, the fermentation is suffered to proceed on the husks a little longer, for the purpose of extracting the colour; and according to the length of this process, we have the *oeil de perdrix*, and the pink and red wines. But this injures the flavour.

When the liquor is transferred to the cask, the discharge of yeast at the bung-hole is encouraged for ten or twelve days; and when the fermentation has become moderate, the bung is put down, and a hole is made by its side. This hole is occasionally opened to give vent to the air, for a space of eight or ten days; when no more air is discharged, fresh wine is introduced, so as to keep the cask constantly full to the bung-hole. This operation is continued when necessary, till the end of December, when the wine generally becomes clear. It is then racked into a fresh cask, and fined. After this it begins to ferment again, losing a portion of its sweetness, and improving in quality. If too sweet, it is not decanted and fined till the fermentation has been renewed by agitation. As the fineness of this wine is one of its essential qualities, and one difficult to obtain, on account of its perpetual fermentation, it is racked and fined a second time, and thus it remains till March. In March it is bottled; yet still it ferments, though corked, and again it begins to deposit. In the best wines, it thus remains from fifteen to eighteen months in the cellar, when it is bottled over again, and is then marketable. The inferior kinds are seldom bottled twice; but an expedient is used instead, to get rid of the sediment. For this purpose, the bottles are ranged in frames with their necks downwards; and when the sediment has been collected in the neck, the cork is dexterously drawn, and again replaced, after which the bottles are filled and completed for the market. There are varieties also in this general process, such as that of suffering the wine to remain in the cask for a year or more on its lees; but we need not enter into these collateral details.

Burgundy Wines.

There is little difference in the practice of Burgundy, except what refers to the retention of the carbonic acid. All else is the same; but great care is taken to clear these wines of their lees, as, from their extreme delicacy, they would soon lose their flavour, and also become sour.

Claret.

In Bordeaux also, the first stages of the process are the same, excepting in as far as a longer fermentation in the husks is used to extract the colour from the red wines. But there is a difference as to the process of sulphuring, which is largely used in these, in the manner as already described. The red wines of Bordeaux are racked about the end of March or the beginning of April, but the white in December; and in all these wines, great care is taken in all those circumstances which relate to cleanliness, however rude the people, and the operations may appear on a superficial view.

Italian Wines.

In the drier Italian wines, the must is allowed to ferment completely in the vat. In some vineyards, a quantity of selected and half-dried grapes is thrown into each tun when the wine is finished, so as to give it sweetness, and prevent the hazard of its running to the acetous stage; a rude and a bad process. In the manufacture of Florence wine, the must is withdrawn from the vat as soon as the head is raised, and the wine is transferred to a cask, where it is only suffered to remain thirty-six hours, when it is again decanted into a fresh cask at the end of a few hours, and so on, until it is clear and marketable. Thus it is completed in a short time, by little more than the process of racking.

In different countries the practices used for procuring the sweet wines vary; but they will be found to depend on one or other of the principles already laid down. In Italy, as in the making of Florence wine, the fermentation is quelled by repeated racking and shifting. Thus the other processes are partly or entirely saved. But it is necessary that very sweet and rich grapes should be used if this process is to be followed. To ensure sweetness, on the principles formerly laid down, the grapes of Tokay are partially dried before they are used; and this is also done for the wines of Cyprus, and for some of those of France and Spain.

Madeira, Port, &c.

In Madeira, the second or insensible fermentation is effected in the pipes, and, at the end of three months, the wine is racked, when a certain portion of brandy is added. In both these practices, it would seem as if the union of the brandy with the wine was less perfect than it might be rendered by a different management of this part of the process. Hence, probably, it

arises, in a great measure, that the taste of brandy is so sensible in many of these wines. In the best, the quantity is said to be about a twentieth part; but, in the worst class of Port wines, it seems sometimes to amount to a third or more.

Sherry.

The grapes are first slightly dried, and then sprinkled with quicklime. They are then wetted with brandy when introduced into the press, and a farther portion is again added to the must before fermentation. It is highly probable that, by this practice, the brandy is more perfectly combined in the wine, and the fluid rendered more uniform; and hence also, probably, it arises, that the taste of brandy is not to be perceived in genuine Sherry, though often found in those baser imitations which are manufactured from the tasteless wines of the Canary Islands, and of other parts of Spain. The remainder of the process for Sherry consists in racking repeatedly at intervals of a month or two; fresh brandy in small quantities being added at each stage of this process.

English Grape Wine.

We may, in conclusion, remark, that in the attempts to make wines in our own country from native fruits, the same rules are of universal application, and that an attention to them would render these domestic processes more complete than they now are, and the results more valuable. In Britain, also, it is easy to make very good wine from immature grapes, by the addition of sugar in the necessary proportions; and these can be procured in almost any season, so that this might even become an object of a petty domestic commerce. Nor is the manufacture limited to the fruit alone, since the leaves and tendrils, by infusion, admit of the same treatment, and with the same results. Very tolerable wine, perfectly resembling the wines of France, can thus be made, and at an expense of little more than the very moderate cost of the sugar.

English Fruit Wines.

Wines may also be made of blackberries and other English fruits, upon the same principles. The addition of brandy destroys the proper flavour of the wine, and it is better to omit it entirely, (except for elder or Port wine, whose flavour is so strong, that it cannot well be injured,) and to increase the strength by augmenting the quantity of the raisins or sugar. In general, the must for wines ought to be made of raisins 6 lbs. or sugar 4 lbs. to the gallon, allowing for that contained in the fruit; and in most fruits, especially the black currant, it is ad-

vantageous to give the juice a boil previously to making it into wine, as this improves the flavour greatly.

Malt Liquors.

Sugar, six pounds is esteemed equal in strength to a bushel of malt: the sugar employed is burnt to colour the beer instead of brown malt, and it has been proposed to employ roasted coffee for this purpose.

The specific gravity of the wort intended for very weak table beer, is generally only 1.01, equal to 2 deg. Baumé; that for ordinary table beer, 1.02, or 3 deg. B.; for table ale, 1.04, or 6 deg. B.; for ordinary ale and beer, 1.06, or 9 deg. B.; for good ale or draught porter, from 1.09, or 13 deg. B.; to 1.1, or 14 deg. B.; and that for keeping liquor, 1.127, equal to 17 deg. B. Every 100 lbs. of this last wort is esteemed to contain 28 lbs. of fermentable matter extracted from the grain. The specific gravity of the wort is reduced by fermentation in an average, 0.075 less than it was. To ascertain the density of their worts, and its reduction by fermentation, brewers used saccharometers of various construction.

In most of these saccharometers, the 0 showed the point at which the instrument floated in river or rain water, and 80 that at which it floated in wort that would just bear up a new laid egg, or a piece of yellow amber, being equal to the specific gravity 1.100. The degrees were called pounds increase per barrel, or sixpennyworths increase in the value of a bushel of malt, merely for mystification. The degrees are therefore reducible to the common expression of specific gravity, by adding first one-fourth the number, for the difference between 80 and 100, and then 1.000 for the specific gravity of water.

According to Blake's saccharometer, Dorchester ale when fit to set shows 84 deg. and when the fermentation is complete, 45 degrees. Ringwood ale, 74 and 30; porter, 66 and 26; table beer, 40 and 22.

One hundred gallons of wort for weak malt liquors, require in winter two gallons of yeast, and in summer only one; for strong liquors, one gallon and a half is sufficient in winter, one in spring or autumn, and half a gallon in summer.

Capsicum and grains of paradise are used to give a pungent taste to weak beer, but to avoid detection, concentrated tinctures are mostly used; and ginger, coriander seed, and orange peel are used to flavour it: besides these, opium, cocculus Indicus, nux vomica, tobacco, and extract of poppies are used to increase the intoxicating quality. Quassia is employed instead of hops as a bitter, but as this does not precipitate the mucilage, the beer soon grows muddy unless kept very cool.

Mild or new beer is made to taste like stale by adding a little oil of vitriol, or some alum; and, on the other hand, stale or sourish beer is made to resemble mild by neutralizing the acid by oyster-shells or chalk.

When strong beer is reduced by adding small beer, publicans usually add molasses to enable it to form a head, and extract of gentian to keep the flavour.

Ale, or Barley Wine.

Pale malt 14 quarters, mashed at three times with 28, 18 and 18 barrels of water, boiled with hops 112 lbs. set with 36 lbs. of yeast, cleansed with 4 lbs. of salt, produced 34 barrels or 1 gallon 1 pint of ale from each gallon of malt. Burton ale yields about 8.88 of spirit in the 100, Edinburgh 6.20, Dorchester 5.56.

Draught Porter.

Pale malt 7 quarters, amber malt 6 quarters, brown malt 3 quarters, mashed at twice with 56 and 48 barrels of water, boiled with Kentish hops 113 lbs. set with 80 lbs. of yeast, salt 4 lbs. and flour half a pound produced 56 barrels of porter, or $3\frac{1}{2}$ gallons porter from each gallon of malt. A third mashing of the same grains produced 20 barrels of table beer. London porter yields little more than 4 of spirit from 100 measures. It is well known that London porter has a peculiar flavour, the origin of which has occasioned much dispute. A French chemist has lately ascribed it to the smoke which it imbibes when in the coolers. Although this may not be the entire cause, it is very probable that this smoky atmosphere has some share in the effect.

Bottling Porter.

Pale malt 4 quarters, amber malt 3 quarters, brown malt 3 quarters, mashed at three times with 25, 12 and 12 barrels of water, boiled with ordinary Kentish hops 100 lbs. set with yeast 52 lbs. and salt 2 lbs.; produced 34 barrels, or 1 gallon and a half of porter from each gallon of malt. Brown stout yields nearly 7 of spirit from 100 measures.

Devonshire White Ale.

Pale ale wort 25 gallons, hops 2 handfuls, yeast 3 lbs. grouts 6 or 8 lbs. When the fermentation is at its height, bottle in strong stone half pints, well corked and wired: it effervesces when opened. The grouts here mentioned are made by infusing 6 or 8 lbs. of malt in a gallon and a half of water, covering it warm by the fire side, and stirring it often: when in full fer-

mentation it is to be boiled down to a thick paste. This is a singular instance of a supposed secret which has been published upwards of a hundred and fifty years. The natives of Kingsbury, in Devonshire, pretend that they alone can make white ale, and there is one family that pretends to the exclusive possession of the secret of making grouts. Now the method of making grouts, and from it white ale, was published in Bauhin's *Historia Plantarum*, as being then the common English ale.

Table Ale.

Very pale malt 12 quarters, mashed at three times with 46, 32 and 32 barrels of water, boiled with hops 62 lbs. set with 114 lbs. of yeast, cleansed by the yeast head being beat in, and let to work out, produced 100 barrels or 4 gallons of ale from each gallon of malt.

CARBONACEOUS MATTERS,

Vary in their qualities according to the substance from which they are prepared; that of the soft woods, as the willow or alder, is best for crayons, and for making gunpowder; that of the harder woods is used for fuel, or for a support for substances exposed to the flame of a blow-pipe. Charcoal of animal substances has the greatest clarifying powder. Charcoal made by a low red heat, not exceeding cherry red, has a dull surface, and is best for clarifying liquids, and probably for making gunpowder, or for fuel. If the heat is carried beyond this point, the charcoal acquires a brilliant surface, and is considerably inferior for clarifying, and probably for every other use. The greatest part of carbonaceous residues are used as fuel or in the manufacture of gunpowder.

Carbonaceous Colours.

Other kinds of charcoal are used as black colours.

Beech black, blue black. Beech wood burned in close vessels; when ground with white lead and oil, it produces a blueish gray colour.

Frankfort black. Made of the lees of wine, or argol, well washed and ground with water; used to make printers' ink.

Noir d'Espagne. Made of cork burnt in close vessels; used as a colour in painting.

Peach-stone black. Peach stones, and the nuts of other stone fruits, as cherries, burnt in close vessels, ground with white lead and oil, it produces the colour called old gray.

Vine-twigg black. Vine twigs burnt in close vessels, bluish black, ground with white lead and oil, it produces a silver-white colour.

Russian lamp black, Noir d'Allemagne. Made by burning the chips of resinous deals, made from old fir trees, in tents, to the inside of which it adheres; mixed with linseed oil is apt to take fire by itself; used as a paint.

Burnt lamp black. Lamp black heated in a covered iron pot to get rid of its greasiness: used as a water colour, fine bone black is sold for it.

Lamp black. From distilled oils of bones burnt in lamps, with a long smoking wick: does not take fire with drying oils.

Wood soot. Collected from chimneys, under which wood is burnt for fuel; contains sulphate of ammonia, it is bitter and antispasmodic.

Bistre. From wood soot, or peat, by pulverization and washing over; an excellent brown water colour, superior to Indian ink for drawings, when they are not intended to be tinted with other colours.

Ivory black, called also *Cologne black, Cassel black.* From ivory shavings, or dust, heated in covered iron pots; used as a dentifrice and a paint; with white lead, it forms a beautiful pearl gray colour.

Carbonaceous Clarifiers.

Of late years carbonaceous matter has been used as a clarifying powder for syrup, and many other articles.

Bone black, animal charcoal, charbon animal, Noir animal. The residuum left after the distillation of bone; reddish; used for making blacking for leather, for moulding delicate founders' work, for clarifying liquors, and for abstracting the lime used in making sugar from the syrup.

Fine bone black, Noir de Paris. Made from turners' bone dust, burned in covered iron skittle crucibles, and ground dry. Sold for ivory black, and when finely levigated, for burnt lamp black.

Prussian blue makers' black, Noir de composition. This is the residuum from whence the prussiate of potash has been elixivated; that of the manufactories which use dried blood, clarifies far better than bone black, or than that of the manufactories that use hoofs.

Charbon mineral. From bituminous slate, burned in covered iron pots, black, easily friable; used to clarify liquids, but is considerably inferior to bone black, and does not abstract the lime from syrup.

[BLEACHING.]

Bleaching, in its broadest acceptation, is the art of removing the colouring matter, whether naturally or artificially acquired, from all bodies in the mineral, vegetable, or animal kingdoms. Its most important applications, however, are to those fibrous substances, so extensively used in the fabrication of the clothing of civilized man, cotton and linen, and to these I shall devote the principal part of this article. I shall treat first of the substances, or agents employed in art; and, secondly, of the processes and manipulations in the order in which they occur.

The materials now used in bleaching are only five in number; viz. water, lime, potash, sulphuric acid, and chloride of lime.

The quality of the water is a consideration of the first importance in the location of a bleachery. No refinement of art has enabled bleachers to surmount the obstacles presented by bad water. Waters impregnated with the muriates, carbonates, or sulphates of lime and magnesia, or with the muriatic, carbo-

nic, or sulphuric acids, in excess, familiarly known by the term, *hard waters*, are unfit for the purposes of bleaching. The small quantity of alkali necessary to precipitate the earthy bases and neutralize the acid, does, indeed, present no serious objection to their use in bucking, nor is there any objection to their use as solvents of the chloride of lime and the vitriolic acid; but their bad washing properties forbids the employment in the dash wheel where the great demand for water lies. These waters are readily known by the property they have of forming curdy or white precipitates, on the addition of a watery, or alcoholic, solution of soap, occasioned by the union of the mineral acid with the alkali of the soap and the consequent displacement of the oil, which floats upon the surface. The protocarbonate of iron is sometimes found in natural waters, and is very objectionable in bleaching processes. Waters containing this salt exhibit a reddish ochery scum on standing, which is also deposited upon the banks of pools and sluggish streams. The presence of carbonate of iron is detected by the addition of a few drops of a tincture of nut galls, which produces a purple precipitate. The ferro-cyanate (formerly *prussiate*) of potash will produce a beautiful blue precipitate, if the water be previously acidulated with a few drops of sulphuric acid. The muriate and sulphate of iron are more rarely found in natural waters, but when they are present, may be detected by the same means. They are alike injurious in bleaching.

Muddy or turbid waters are obviously unfit for the purposes of bleaching, and particularly for the last washings. They may answer for the earlier processes, provided spring or other clear water can be obtained for rinsing. This is the only species of impurity in water which can be remedied by filtration through sand and gravel, which is an indispensable operation on streams whose banks are muddy and liable to frequent and sudden inundations.

The waters of many streams, particularly those which flow through marshy grounds, are tinged of a yellowish or greenish hue, owing to their holding in solution certain vegetable matters. This is one of the most formidable obstacles to a good bleach, and has not yet been surmounted by art.

From the foregoing remarks, it is obvious that the means of judging of the fitness of water for bleaching purposes are extremely simple, and attainable by every individual without even the humblest pretensions to science. A water that is limped and colourless, that does not precipitate an alcoholic or watery solution of soap, (or, in common language, that is *soft* and will *wash well*,) and that is not discoloured by the addition of an infusion of nut gall, or an acidulated solution of ferro-cyanate

of potash, or that does not deposit an ochery matter on the banks of water courses,* may be safely relied upon as in every respect well adapted to the processes of bleaching.

Lime suitable for bleaching should be recently and thoroughly burned, and colourless; in other words, lime that is white, and in other respects adapted to masonry, will answer the bleacher's purpose.

Potash, the vegetable alkali, is another important agent in the bleaching art. This article is never found pure in commerce; besides accidental impurities, it is always united, to a greater or less extent, with carbonic acid. Commercial potash is a mixture of pure potash with the subcarbonate of potash, sulphate of potash, siliceous, minute portions of other earths, and occasionally of undecomposed vegetable matters. These foreign matters exist in very variable quantities in the potash of commerce, and it becomes an important object with the bleacher to find a convenient method of determining the exact amount of real alkali in it, and of course the comparative value of the different lots offered in the market, as a guide to aid him both in his purchases and in the subsequent use of it in his processes. The alkalimeter of Dr. Ure, founded on the quantity of sulphuric acid required to neutralize 100 grains of potash, is a convenient instrument for this purpose. One hundred grains of pure potash will require 105 grains of concentrated oil of vitriol for perfect saturation. The method of procedure is this:—provide a glass tube, sealed at one end, 9 or 10 inches long, and three-fourths of an inch in diameter, and graduate it into 100 equal parts. It is convenient to have the graduation commence a little below the extremity of the open end. The exact contents of this measure is not important, provided the graduation is exact. Such graduated tubes can be obtained at any of the glass houses. Into a tube of this description introduce 105 grains of concentrated sulphuric acid of a specific gravity, 1.850, or 170° on Tweedale's Hydrometer, and fill up the remaining graduated spaces with water; decant the mixture into a wider lipped glass vessel, and stir with a glass rod till the union of the acid and water be complete. Now, as the whole 100 measures contain a quantity of oil of vitriol equivalent to 100 grains of pure potash, it is obvious that each measure of the liquor in the tube is adequate to the neutralization of one grain of potash, and the number of measures required for the neutralization of a solution of 100

* The ochery matter frequently observed to be deposited on the banks of rivers from the oozing of minute springs, should not be mistaken for a deposit from the water of the stream itself, as such deposits are generally too inconsiderable to affect the general purity of the water.

grains of any commercial sample is an exact measure of the quantity of real potash contained in it, and, *vice versa*, the number of degrees remaining in the tube is the measure of the impurities contained in the sample. The point of neutralization is ascertained as usual in such cases by cautious additions of the acid, stirring the mixture on every addition, and trials of the changes of colour produced on litmus and turmeric papers by the liquid. It is proper to caution the operator against a frequent source of error, pointed out by Dr. Henry in his excellent directions for the manipulations in alkalimetry, from the presence of the disengaged carbonic acid, which, by acting on the litmus paper, may lead him to infer an excess of sulphuric acid. This source of error may be avoided by warming the liquor towards the last of the process, by which means the disengaged carbonic acid is expelled.

Of the oil of vitriol of commerce, one of the next most important agents in bleaching, little need be said. It is generally sufficiently pure as it comes from the manufacturer for every purpose of the bleacher. It should be colourless, and have a specific gravity of 1.850, or 170° T. If it have a specific gravity greater than that, its purity may be suspected. The usual impurities are sulphate of potash and sulphate of lead. The latter may be detected by a precipitation, on the acid being largely diluted. I am not aware that either have any injurious effect in the bleaching process. But the acidimeter is the readiest method of determining the comparative value of commercial samples, and this is no other than the alkalimeter just described, only reversing the method of procedure;—100 grains of pure potash are to be dissolved in 100 measures of water in the graduated tube, and portions of the solution added cautiously to 105 grains of the oil of vitriol to be operated on, previously diluted with four or five times its weight of water, till the acid is neutralized. The number of parts, on the graduated tube of the alkaline solution, required for this purpose, will determine the per centage of real acid contained in the sample;—if eighty parts of the one hundred degrees are required for this purpose, then is there eighty parts of real acid in every one hundred parts of the sample.

The last article essential in the bleaching process, is the chloride of lime, or bleaching powder. The introduction of this compound constituted an important era in the history of the bleaching art. What was formerly a work of several weeks, is in modern bleaching, accomplished in as many days, and with a proportional diminution of labour, and great reduction in expense. The tedious exposures to sun and air, to which in the old method the goods were necessarily subjected, are en-

tirely superseded by the use of chloride of lime. The manufacture of this article is described under the head of chloride of lime in this work. It is a dry white powder, having a slight smell of chlorine and a peculiarly strong acrid taste, not very unlike the muriate of lime. It is partially soluble in water, to which it imparts its smell and bleaching power. The undissolved portion is an hydrate of lime united with a small proportion of chlorine. The value of chloride of lime depends wholly on the amount of chlorine it contains. We meet with very variable proportions in the commercial specimens. Bleachers generally judge of the strength from the specific gravity which it imparts to the watery solution. If the powder be dry and have the odour and taste of a good article, the specific gravity is not an indifferent measure, though I have not found it uniformly correct. 5 lbs. of the best bleaching powder should impart to its solution in an ale gallon of water, a specific gravity of 1.025 or 5° T. But a more correct test of the value of this article is to be found in its power of discharging the colour from a diluted solution of indigo in sulphuric acid; for directions for using this test the reader is referred to the article, which treats of the manufacture of bleaching powder in this work. It ought to be known to the bleacher that chloride of lime loses strength by exposure to the air, and to a certain extent even when it is kept in close casks; by free exposure to the air the chlorine escapes, or is rather expelled from the lime by the joint operation of the carbonic acid and moisture of the atmosphere, and a carbonate instead of a chloride of lime remains; no more than one cask, therefore, should be allowed to be open at any one time, and that should be kept as much excluded from air and moisture as possible.

I will now proceed to describe the various processes of the art in the order in which they occur in the bleaching of cotton shirtings and sheetings.

The Steep.

The goods as they come from the loom are impregnated with flour, paste, or starch, used in the process of manufacture. To free them from this foreign matter, they are thrown in loose bundles, each piece by itself, into any large vessel, or cistern, capable of containing the quantity to be operated on, which I will suppose throughout this treatise to be one ton net or 2000 lbs. The form of this vessel is a matter of no importance whatever; a common wooden cistern, such as is used for the scouring and bleaching liquors will answer every purpose, provided there is a means of warming the water in winter by steam; but if this cannot be conveniently done, a spare bucking keir may be

made use of when artificial heat is required. On the introduction of every layer of cloths sufficient water should be admitted into the steeping vessel to wet them, and, in order to secure this object effectually, while one man is employed in putting the goods into the cistern, another should tramp them into the water. It is better that no more water should be used than is sufficient to cover the goods when pressed down. In this state the cloths should remain till a gentle fermentation is produced, which may be known by the appearance of a frothy scum upon the water, and a sour smell from the cistern. In fact the acetous fermentation of the paste, and perhaps some vegetable principle of the cotton along with it, has taken place; its elements have assumed new combinations, and become more soluble in water. It is probable also that the acetous acid which is formed, may at this early stage exert a solvent power on the natural colouring matter of the cotton highly beneficial. The time requisite for the steep depends much on the season of the year, or rather on the temperature to which the goods are exposed; during the summer months twenty-four hours, and sometimes less, will be found sufficient for this purpose; in ⁿspring and autumn from one to two days are necessary; and in winter artificial heat is indispensable to despatch in business; the acetous fermentation is very sluggish below 50° F^t.: it takes place readily at 60°, but does not attain its greatest activity below 80°, or perhaps 90°. When artificial heat is used, care should be taken not to allow a temperature approaching to a scald, which is supposed to produce a change on the starch or paste, unfavourable to the necessary fermentation when the proper temperature is afterwards acquired. It is scarcely necessary to remark that the steeping process, if carried too far would endanger the strength of the fabric. Some bleachers employ for the steep the spent alkaline leys instead of clean water; a practice highly objectionable; 1st, because it retards the fermentation; 2nd, because this alkaline liquor is already loaded, perhaps saturated with the colouring matter of the cloth, and would be more likely to deposite than to take up an additional quantity at the low temperature of the steeping liquor; and, thirdly, because the acetous acid of the fermentation must, by combining with the alkali of the ley, have the direct effect of precipitating the colouring matter, with which it was previously united, directly upon the cloth. It is a singular circumstance that a practice so fraught with objections; and so opposed to the acknowledged theory of bleaching, should have been either passed over in silence, or noticed with commendation, by all the respectable writers, who have treated of the subject. The fermentation of the *steep* might be greatly expedited by the use of a very

small quantity of yeast made from damaged flour, which might be deposited near the centre of the lot; but in this, as in the introduction of the slightest innovation upon established practices, the enlightened bleachers may calculate on encountering the prejudices of old workmen in the art. After the steep the goods are to be opened out of the band, or bundle, in which they are usually made up, and well washed in the dash wheel. Some bleachers improperly omit this washing.

The Liming.

For this purpose take one bushel of good quicklime and reduce it by slaking to a dry powder; introduce it into a vessel capable of containing from 60 to 80 gallons, (a common rum puncheon answers a good purpose,) and fill it with water; agitate the mixture by stirring, till it acquire the consistence of milk;—lay into the bottom of the keir a stratum of cloth having the bands of the folded piece previously made very loose, and while one man is employed in stirring the lime mixture, let another dash a bucket or two of it over the cloth, which being previously wet absorbs the liquid very readily; let another layer be put in and wet down with the lime mixture, and so on till the operation is completed. As the mixture gets low and of a thicker consistence in the lime cask, more water must be added till the lime is all used, and the cloth all in the keir; it is better, indeed, to add a fresh bucket of water to the mixture for every bucket that is withdrawn, till towards the very last of the lot. The manipulations in this stage of the business will be very easily comprehended when it is understood that the object is to diffuse a bushel of lime as equally as possible through a quantity of water sufficient to fill the keir to the grating, upon which the cloth rests, which will require from 300 to 400 ale gallons, and to spread this mixture evenly over the cloth. The agitation of the lime liquor must not be so violent as to keep suspended any lumps of lime that may remain in the powder after slaking, which must be rejected at the last; for such is the activity of this agent that it is sure to endanger the fabric where it is allowed to remain in any considerable quantity in contact with it during the boil. The cloth should be heaped a little about the vomiting pipe, so that the liquor as it falls from the pipe may subside more towards the side of the keir than it otherwise would do; much, however, depends upon the exact form of the pipe, and the violence of the ebullition; it should be the bleacher's aim to watch the boiling carefully, and adopt such little expedients from time to time as may ensure a regular and even distribution of the liquor over the surface of the cloth; and percolation through it; this

is important in all the boilings, but particularly in the liming, where owing to the very sparing solubility of the lime, an uneven distribution of the liquor may not only fail to produce the necessary effect upon some unexposed portions of the goods, but, by an unequal deposition of the solid particles of lime, produce such an accumulation upon other portions as to injure the texture. The fire may be kindled under the keir as soon as the first layer of cloth is introduced, and wetted with the lime liquor. The boiling should be kept up briskly, at least eight hours; ten hours' boiling will not endanger the cloth;—it is a good rule to boil in this as well as in the subsequent buckings in potash nine hours.*

As soon as the boiling is completed, the goods may be cooled down by the admission of cold water, and removed from the keir. When taken from the keir the pieces are to be loosed from the band; edged up, (that is, pulled over from end to end by one selvaige to shake out the folds and *crimps*,) and carried to the dash wheel. Owing to the insolubility of the lime the washing out of this boiling requires greater attention than from any other. Some bleachers edge up and wash a second time before the potash boil; but this is unnecessary. If the dash wheel be well supplied with water, ten minutes' washing is generally sufficient for any purpose; the best criterion, however,

* The whale boiler or keir, so called, is now almost universally adopted in bleacheries, both in England and the United States. The bottom is composed of iron or copper with a broad horizontal flange turned up at the outer edges, to which a wooden curb is attached by bolts and nuts. This curb is usually made widest at the top; the dimensions of a curb for boiling 30 cwt. of cloth are usually 7 feet deep, 6 feet diameter at bottom, (that is, the grate upon which the cloth rests,) and 7 feet at the top. The bottom part should have a capacity of 300 to 400 gallons. A vertical metallic tube 5 inches diameter, and open at both ends is firmly attached to the grate by a side flange, and terminates below the grate within two or three inches of the bottom of the keir and above the grate within six or eight inches of the top of the curb. This tube is generally made too small, and does not allow the liquor to pass up as freely as it should do. But the particular object of this note is to point out the advantage of reversing the form of the curb and placing the largest diameter at bottom, and the smallest at top. The object of this change in the form is to obviate a difficulty which bleachers often experience in the common keir, that of the goods rising in the curb and pressing up the cover to the great loss of heat, and sometimes to the complete defeat of the boiling; for after the cloth has once risen in this way, it is very difficult to get it back again till the keir is cooled down. I have tried the change proposed with great advantage, and indeed with complete success in obviating the difficulty mentioned.

With regard to the question, whether the employment of steam, or the direct application of fire to the keir be most advantageous, I do not consider it an important one, but prefer the latter; first, because a little higher temperature may in this way be obtained than can be conveniently obtained by steam; and, secondly, because the apparatus may be constructed at a less cost in the first instance, and maintained at less expense for repairs. I need scarcely add, that where steam is employed for this purpose that the keirs may be constructed wholly of wood.

by which to judge of the amount of washing required out of either the lime or the potash boiling, is the colour of the water which runs from the dash wheel; when this ceases to be muddy, or discoloured, we may safely infer that the washing has been sufficient. From the dash wheel the pieces are thrown again into bundles preparatory to the

First Potash Boiling.

Dissolve in an iron kettle by heat 100 lbs. of the best American potash in 25 gallons of water; add to this solution while hot 25 lbs. of fresh slaked lime and stir the mixture half an hour; allow it to stand till the sediment subsides, and then lade off the clear liquor into another clean iron vessel. This is a standard potash ley, each gallon of which contains four pounds of potash, and should have a specific gravity of 58° Tweedale's hydrometer. Put 16½ gallons of this solution into the boiling keir and add water till it stand 6 to 8 inches above the grate; kindle a fire under the keir and lay in the cloth with the bands of the bundles quite loose; proceed in the boiling in all respects as in the boiling in lime, and keep up a brisk ebullition 8 or 9 hours. It is usual to put the goods into the keir in the morning, and, after boiling, to allow them to remain in it over night, and cool gradually. This will answer very well in the potash boiling; but after the boiling in lime I should hesitate to allow the cloth to lie in the keir over night without being previously cooled down by the admission of water. In cases of great urgency it is practicable to buck twice in twenty-four hours.

From the boiling keir the cloth is again returned to the wash wheel. It is not necessary to edge up the pieces in this washing. The liquor remaining in the keir after boiling is very dark coloured, and surcharged with the colouring matter of the cloth; it has lost in a great measure its causticity; if muriatic acid be added to a portion of this liquor, the colouring matter is precipitated of a dark greenish hue. By evaporating this residuum liquor till it acquire the consistence of thick treacle, and then exposing it to the heat of a reverberatory furnace; the vegetable matter may be burned out and dissipated, and the alkali recovered in the form of pearlash, or the subcarbonate of potash. This was formerly practised in England, but has, I believe, now fallen into disuse. The expediency of it depends wholly on the relative value of the alkali on the one hand, and of labour and fuel on the other. Where fuel and labour are comparatively cheap, and the alkali high priced, as in Lancashire in England, this may, in some instances, be an economical practice; but where the reverse of this is true, as in the United States, the product would scarcely reward the attempt.

After washing, the cloth is allowed to drain, and is then prepared for the solution of chloride of lime.

Blanching Liquor.

The solution of the chloride of lime is known to English workmen, and, I believe, very generally to our own, by the vulgar appellation of *chemic*, a term scarcely to be tolerated in a work having the least pretensions to scientific propriety. As a popular name, however, seems almost indispensable in a treatise designed for practical men, I shall designate it by the more appropriate appellation of *Blanching Liquor*. It is prepared by adding 50 lbs. of the best chloride of lime, or bleaching powder, to 50 gallons of water, stirring the liquor occasionally for ten or twelve hours, and then leaving it to settle; it is most convenient to commence this process in the early part of the day, and allow the liquor to stand over night; by this means a firmer sediment is obtained, and the clear liquor is more perfectly separated from it. Add this clear solution to a sufficient quantity of water for covering the lot of cloth, (2000 lbs. as before mentioned.) The goods are to be immersed in this liquor, and particular care must be used that the bands be quite loose, and that the quantity of liquor be sufficient to cover the pieces without compressing them too hard. This solution is not so penetrating as the acid liquor, and the cisterns should have a capacity compared with the cisterns for the sours, as 4 to 3, in order that the cloth may be more fully exposed to the action of the liquid. Two thousand pounds of cloth will require for the solution of chloride of lime a capacity of about 360 cubic feet, and for the sours 270. The cloth should remain in the blanching liquor about 10 hours. It is then thrown upon a grated wooden flooring which extends about one half the cistern, and after draining an hour or two, is ready for

The First, or Brown Sours.

Fill the cisterns for the reception of the goods to within three-fourths of their depths of the top with water, and add to it 40 lbs. of concentrated oil of vitriol, and stir the mixture well till the acid and water be thoroughly incorporated. The liquid will then have a specific gravity of $1\frac{1}{4}^{\circ}$ or 2° on Tweedale's Hydrometer, and a degree of acidity to the taste, about equal to that of lime or lemon juice. As the souring liquor is not often entirely changed, no very exact rule can be given for replenishing the cisterns with acid; as a general rule, however, 40 lbs. of concentrated vitriol per ton of cloth for each souring will be found sufficient. The specific gravity may be some guide, but this is liable to be influenced by other matters derived from

the cloth. On the whole, the taste is the surest guide for the practical bleacher. Goods are rarely injured by too strong sours, if proper precaution be taken to prevent any parts of them from drying with the acid in them; if this precaution be neglected, the destruction of the fabric is certain;—the reason is obvious,—if the cloth dry with the souring liquor in it, the watery parts alone evaporate, and from being impregnated with a very diluted, it becomes intimately united with a highly concentrated acid; on this account it is always better where the goods cannot be washed out of the sours, after the usual time, to allow them to remain in the liquor, in preference to leaving them long exposed to the air; or, if it be necessary to withdraw them from the liquor to make room for another lot, they should be kept wet and excluded as much as possible from the atmosphere. Damage from this source is always to be suspected where certain circumscribed spots of bleached cloths are observed to be tender, while the general texture of the fabric is sound. Ten or twelve hours' immersion in the sours is sufficient, but an hour or two, more or less, is not material. After draining, return the goods to the dash wheel.

Second Potash Boiling.

The method of proceeding in this is precisely the same as in the first boiling in potash, except that only one half the quantity of potash is used. The boiling, washing, blanching, and souring operations are repeated in the same order and manner as already described. As the goods are, however, become more free from colouring matter, it is important that the second souring and blanching operations should be performed in separate cisterns; these cisterns are generally called by the workmen the *white chemic* and *white sours*, in contradistinction from the first liquors denominated the *brown chemic* and sours. The liquor of the brown sours should be changed after every 20 or 30 operations; but those of the other cisterns not oftener than once a year, if proper precautions be taken to preserve them from accidental impurities. Great care should be used that the cloth be thoroughly washed out of the last sours; for, if any acid remain in the cloth when dry, it certainly will be injured. In all the other washings it is usual to wash two pieces in each compartment of the dash wheel; but, in order to ensure a perfect washing out of the last sours, it is better to put only one piece in a compartment.

After the last washing the goods are passed through a trough of clear water, squeezed, and dried.

The order of the processes, then, as described in the foregoing remarks, are summarily these:—

1. Steep;
2. Wash;
3. Boil in one bushel of lime;
4. Wash and edge up;
5. Boil in 67 lbs. of potash;
6. Wash;
7. Immerse in a solution of 50 lbs. of chloride of lime;
8. Immerse in sours containing 40 lbs. of oil of vitriol;
9. Wash;
10. Boil in 33 lbs. potash;
11. Wash;
12. Immerse in the solution of chloride of lime;
13. Sour as before;
14. Wash;
15. Rinse and squeeze.

The whole amount of materials used is one bushel of lime, 100 lbs. of potash, 50 lbs. of chloride of lime, and 40 lbs. of oil of vitriol for 2000 lbs. of cloth.

Bleaching for Calico Printing.

The bleaching for calico printing differs in nothing materially from the foregoing, except in the number and severity of the operations. Indeed, for calicos intended for blue dipping, as well as for several other styles of printing, the processes described will be found to answer every purpose. For goods intended for the madder dye, another course of work is generally advisable, and often indispensable: by the term *course*, in bleaching reference, is usually had rather to the boiling than to an entire series of operations of boiling, blanching, souring, and the washings; in the present case I would advise another boiling in 25 lbs. of potash, souring and washing out of each. Calico may be bleached of a beautiful whiteness, and yet contain matters that will resist, or materially modify, the action of the madder and quercitron bark dyes. Calicos intended for printing are passed twice over a red hot iron semicylinder; the object of this firing, or singeing as it is called, is to burn off from the side of the cloth, intended for printing, the nap or pile composed of the loose ends of the filaments of cotton.

Such are substantially the operations of bleaching cottons, as practised for a series of years in one of the largest establishments in this country. From personal knowledge the writer can assert with confidence that they will in all ordinary cases be found safe and effectual; how far they may be modified or abridged, and yet secure the same uniform result, he is unable to decide with the same confidence. Certain it is, however, that the number and order of the operations may be varied, and

in some respects inverted, and yet afford a good bleach. Scarcely any two bleachers pursue exactly the same course of work. Throughout the state of Rhode Island, and in some other parts of the country, the bleachers use no lime whatever, but confine themselves to two heavy boilings in potash; this was formerly the English practice, but the use of lime is now, I believe, nearly universal in England for the first boiling. The detergent, or solvent, properties of lime, in relation to all oily matters, appear to be greater than those of potash, and I am inclined to think in relation to some natural colouring principles of the cloth also; in proof of this, I have often remarked that where from any cause the lime boiling had been imperfectly performed, three, and even four subsequent boilings in potash were insufficient to prepare the cloth for dyeing well in madder.

Some intelligent bleachers, with whom I have conversed on the use of lime in bleaching, entertain fears lest its corrosive qualities should injure the texture of the cloth; but these apprehensions are groundless, if the liming process be conducted in the manner already pointed out. I have never witnessed but one instance of damaged cloth from this cause, and that originated in an attempt to extend the use of it. Having noticed so often the almost indispensable importance of the lime boil to a good bleach for madder dyeing, I determined on trying the effect of a second boiling in lime, as a substitute for one, or both, of the usual boilings in potash. The result was, that a few pieces in the top of the keir, where there was a considerable deposition of solid lime, were made very tender, while the great mass underneath remained uninjured. Fearing lest the operation might have been too severe to undergo another boiling, I omitted it as well as the second immersion in the blanching liquor, and used the cloth for some styles of work not requiring a very thorough bleaching. I do not regard the experiment as decisive against the extension of the use of lime, but record it merely to show the extreme caution necessary in applying it. Had I taken the precaution to protect the upper layer of pieces more effectually from the coarser particles of the lime, by covering the goods with several thicknesses of coarse gray cloth, to operate as a filter, it is probable that no injury would have been done.

The practice of passing the goods immediately from the solution of chlorine of lime to the sours without washing intermediately, has often been objected to by calico printers on the supposition that the deposition of the sulphate of lime in the fabric has an unfavourable effect on the madder dye; indeed a prejudice was a few years since got up in Lancashire against the use of lime in any shape in bleaching for calico printing,

but both opinions appear to have originated in partial or imperfect observation, and are now discarded by all intelligent printers. The omission of the washing between the immersion in the solution of chloride of lime, and the sours is sometimes attended with inconvenience to the workmen, owing to the liberation of the chloride by the union of the acid with the lime. This, however, is not much regarded where there is a suitable ventilation of the building, when the liquor is not too strong, and the goods have been allowed to drain sufficiently before immersion in the sours;—besides, the bleaching effect is nearly double what it is when the goods are washed between the two immersions; all the chlorine, which in the last case would be washed away in the dash wheel, is set at liberty in the sours, and most of it is taken up and becomes effective on the cloth.

The action of the vitriolic sours as well as of the solution of chloride of lime on the cloth, may be much increased by using them at a temperature of from 80° to 90° Ft., and the sours even at a heat of 120° or 130° , without endangering the texture of the goods. The use of warm sours is now very general, though not universal, with the English bleachers, and is partially adopted in the United States. Some bleachers confine it to the last sours. The action of acid, and indeed chemical action generally, is quickened by an increase of temperature, and it may be supposed that the only advantage in the present case would be that of expediting the process: I am inclined, however, to ascribe to the warm liquid a dilatation, or relaxation, of the fibre of the cloth, which enables the acid to penetrate, and act upon it more thoroughly, as well as more speedily than it otherwise would do. I should decidedly recommend the adoption of warm sours in bleaching for calico printing, if not in ordinary bleaching. I do not regard the use of a warm solution of chloride of lime so desirable, and it is attended with some little risk of injury to the cloth; when employed, the temperature should not exceed 90° , nor should the goods be allowed to remain in the liquor over five or six hours.

Closely connected with this subject is the influence of temperature generally on the processes of bleaching; it has been often remarked by bleachers, that goods do not bleach so well in winter as in summer; and this is more frequently observed in the bleach for calico printing, where slight variations are sooner detected. An English calico printer of great experience, now resident in this country, informs me that he considers the difference here fully equal to an additional boiling in potash in winter, and that the same treatment will not produce a good bleach here in the winter season as in England. I am

induced to think, however, that an effect is here wholly ascribed to temperature, which is partly attributable to another cause;—a difference in the method of manufacture. In England, the west of calicos designed for printing, is invariably spun upon *mule* spinning frames, whereas in all the factories of Massachusetts and New Hampshire, as well as in many of those of the other states, it is invariably spun upon the water, or throstle frame; in the latter case, more twist and greater compactness is given to the yarn, and of consequence to the woven fabric, which, although a real excellence in the cloth for wear and durability, presents greater obstacles to the penetration and action of the bleaching liquors than the cloth manufactured from mule-spun west. It may be objected, that this explanation assigns no reason for the difference observable between the effects of the ordinary operations of bleaching in summer, and in winter; in reply to this objection, I can only say, that there is far less difficulty in determining what amount of materials and severity of treatment will produce a given effect generally, than what is the *minimum* of materials and labour, sufficient to produce the same results under the most favourable circumstances. It is not improbable that the treatment already recommended is unnecessarily severe during the heat of the summer months, and that the experience of an English bleacher may be as inapplicable to the practice of the art in our climate in summer as in winter. During a large experience in the art of calico printing, I have really had occasion to complain of this bleach in the summer months, when it is scarcely possible but the operations described may have been frequently more or less imperfectly performed from negligence or inadvertence of the workmen or from other unavoidable causes; yet in winter, I believe, imperfect bleaching is with all printers in this country a source of frequent and often perplexing miscarriages.

There is another circumstance growing out of this method of spinning the west of calicos, which has caused considerable embarrassment to the calico printers, and deserves to be mentioned here. It arises from an accumulation of the oil used in oiling the spindles about the base of the bobbin, upon which the yarn is spun, and caused by the carelessness of the person employed in oiling the spindles; the oil is suffered to spill over the outside of the bobbin, and descending to the shoulder or base, accumulates there; if the yarn be raised a little from the base of the bobbin the lower strata will be observed to be moist with oil. In the process of manufacture this oiled yarn attracts dust from the atmosphere and from whatever it may come in contact with, and if the cloth be narrowly in-

spected as it comes from the loom, dark transverse lines may be observed in it, of from six to eight threads in width, and these lines correspond exactly with the last *picks* from the bobbin. The distance of these lines asunder depends on the quantity and fineness of the yarn upon a bobbin, and the number of picks in a given space; it ranges from six to eight inches in different descriptions of calico; but, whatever be the distance, it will always be found nearly uniform in the same description of cloth, or, if the spaces vary, they will be found to be twice, three times, or some other simple multiple of the distance woven by a single bobbin. I am thus particular in the account of this evil, because the real cause of it was for some time unsuspected, and the source of considerable loss and perplexity in two of the largest manufacturing and calico printing establishments in New England, and may become so to others. It is an obstacle that no foreign bleacher would be prepared to encounter. Goods of this description will bleach beautifully white, yet on passing them through the weakest madder dye, orange, or copper coloured stripes will appear in place of the dark ones observed in the gray state, which totally unfit the cloth for any style of printing requiring a light ground, or light colour. The only remedy for this evil is great attention to the lime boiling; where this has been imperfectly performed, the difficulty can scarcely be remedied by any subsequent boilings in potash. I have sometimes boiled in potash as many as five times, and given the cloth the corresponding number of immersions in the acid and blanching solutions and washings, and yet failed to remove the evil. This shows the great superiority of lime over potash for removing all oily matters from the cloth, and its indispensable use in bleaching for calico printing. I have never encountered this difficulty except in winter months, or during the prevalence of cold weather in spring and autumn. The first cause may be, to a great extent, prevented by the manufacturer by *countersinking*, or reaming out, the upper orifice of the bobbin, and by the more careful use of oil in applying it to the spindles; but the bleacher need not rely upon a thorough correction of the evil from that source; his processes must be sufficient to remove it in all cases, or otherwise calculate on sad disappointments; for workmen will be careless, and the most scrupulous care and attention cannot prevent occasional accidents. The operation of singing appears to fix all oily matters upon the cloth, and render their removal more difficult for the bleacher. I have sometimes thought of boiling the cloth in lime before singing, but it would be attended with an additional expense of drying and perhaps

calendering, which last operation is objectionable also on account of its *laying* the pile which it is the object of the singeing process to remove.

The quality of the stock, of which the calico is manufactured, is another circumstance calculated to modify very much the effects of the bleaching agents upon it. Some cottons are naturally of the colour of *nankins*, and others nearly white, (at least they have that appearance in the unwrought state.) I am unable to say whether the different species require a severity of treatment exactly corresponding with the difference in the depth of colour. It is so said by some writers, and the opinion is, probably, nearly correct.* The foregoing directions for bleaching, however, have reference only to calicos fabricated from North American, and for the most part from New Orleans and upland, cottons, which are very white compared with many species grown in other parts of the world.

Coarse cloths, and other things equal, are bleached with much greater facility than fine: fine yarns have necessarily more twist in them than coarse, and therefore present greater mechanical obstacles to the penetration of the bleaching liquors; in like manner the closeness and firmness of the texture of the woven fabric has great influence in resisting the action of the bleaching agents. Few bleachers, I apprehend, are fully aware of the variations in the amount of materials and labour which these differences in the fabric will admit of. The foregoing remarks may be considered as applicable to cloth manufactured from yarn of forty skeins to the pound, and having about eighty threads to the inch, warp and weft; an equal weight of No. 14 shirtings may be bleached (even for madder dyeing) for from one-half to two-thirds the amount of materials and labour.

I subjoin the following as the order of the processes, and the amount of potash used at a large establishment for bleaching and calico printing in Massachusetts, for which I am indebted to the politeness of the superintendent of the works. The reader will observe it is somewhat more severe than that recommended in the foregoing pages. The quantity of cloth operated on is 3000 lbs.

Bleach for Madder Dyeing on No. 40 Calico.

1. Steep;
2. Wash;
3. Boil in lime;
4. Wash twice, but not edge the pieces;

* Berthollet says that, in general, yarns of a yellow colour bleach with more difficulty than those of a gray hue, bordering on brown.

5. Boil in 74 lbs. of potash;
6. Wash;
7. Boil in 40 lbs. of potash;
8. Wash;
9. Immerse in a warm solution of chloride of lime;
10. Sour (warm;)
11. Wash;
12. Boil in 20 lbs. of potash;
13. Wash;
14. Immerse in a warm solution of chloride of lime;
15. Sour as before;
16. Wash;
17. Boil in 20 lbs. of potash;
18. Wash;
19. Sour;
20. Wash;
21. Rinse and squeeze.

Bleach for Blue Dipping, (Blue and White,) No. 90 Cloth

1. Steep;
2. Wash, (in cases of urgency this washing is omitted;)
3. Boil in lime;
4. Wash;
5. Boil in 40 lbs. of potash;
6. Wash;
7. Immerse in chloride of lime (warm;)
8. Sour (warm;)
9. Boil in 27 lbs. of potash;
10. Wash;
11. Rinse and squeeze.

The same as the last for white goods, only with an additional souring and washing after the second boiling in potash.

Bleaching of Linen.

The bleaching of linen differs from that of cotton in nothing but the number and severity of the operations. The colouring matter of linen is less soluble, and probably more abundant, than that of cotton. About double the amount of materials and number of operations of boiling, washing, souring, &c., are required to produce a good white.

Theory of Bleaching.

The theory of bleaching is not well understood. The experiments of Mr. Kirwan, published in the Irish Transactions for 1789, throw the most light of any that have appeared on the na-

ture of the colouring matter of cotton and linen. He precipitated, by means of muriatic acid, the colouring matter from an alkaline ley, in which linen yarn had been digested, and found it to possess the following properties:—

When suffered to dry for some time on a filter, it assumed a dark green colour, and felt somewhat clammy, like moist clay.

A small portion of it was perfectly insoluble in sixty times its weight of boiling water.

The remainder being dried in a sand heat, assumed a shining black colour; became more brittle, but internally remained of a greenish yellow, and weighed one ounce and a half. By treating eight quarts more of the saturated ley in the same manner, he obtained a farther quantity of the greenish deposit, on which he made the following experiments:—

“1. Having digested a portion of it in rectified spirits of wine, it communicated to it a reddish hue, and was, in a great measure, dissolved; but by the affusion of distilled water the solution became milky, and a white deposit was gradually formed: the black matter dissolved in the same manner.

“2. Neither the green nor the black matter was soluble in oil of turpentine, or linseed oil, by a long continued digestion.

“3. The black matter being placed on a red hot iron burned with a yellow flame, and black smoke, leaving a coaly residuum.

“4. The green matter being put into the vitriolic, marine, and nitrous acids, communicated a brownish tinge to the two former, and a greenish to the latter, but did not seem at all diminished.

“Hence,” says Mr. Kirwan, “it appears that the matter extracted by alkalies from linen yarn, is a peculiar sort of resin, different from pure resins only by its insolubility in essential oils, and in this respect resembling lacs.” He then proceeded to examine the powers of the different alkalies on this substance: eight grains of it being digested in a solution of crystallized mineral alkali, saturated at a temperature of 62° , instantly communicated to the solution a dark brown colour; two measures (each of which would contain eleven pennyweights of water) did not entirely dissolve the substance. Two measures of the mild vegetable alkali dissolved the whole.

“One measure of caustic mineral alkali, whose specific gravity was 1.053, dissolved nearly the whole, leaving only a white residuum.

“One measure of caustic vegetable alkali, whose specific gravity was 1.039 dissolved the whole.

“One measure of liver of sulphur, (sulphuret of lime,) whose specific gravity was 1.170, dissolved the whole.

“One measure of caustic volatile alkali dissolved also a portion of this matter.”

So far the theory of the art is very simple and obvious; the colouring matter of the cloth consists in a great degree of a resinous substance, soluble only in alcohol, the alkalies, sulphuret of lime,* and we may add, from more recent experience, in lime water, and perhaps to a degree in caustic magnesia; and during this solution the alkali loses its caustic property, and becomes comparatively mild even to the taste. But the alkaline solutions will not remove all the colouring matter from the cloth; after a few boilings the solvent power of the alkali, even of fresh portions, seems to cease, and no more colour is extracted till the cotton or linen, as the case may be, is exposed to the action of air and sun, or to a solution of chlorine, or some of its compounds with the alkalies or earths; after which, although the effect of these last agents is to whiten the fibres, the alkali recovers its solvent power over this principle in the cloth, and when digested upon it loses again its caustic properties, and what is more remarkable acquires a brown colour. The most ample experience has demonstrated the necessity of employing these agents *alternately* in order to a perfect bleach; neither will effect the object singly, nor both consecutively, whichever may be applied first. It is probable that the peculiar effects of sun and air, and chlorine, and its compounds, upon the colouring matter of cloth are referrible to the same principle, and that that principle is oxygen; it is certain that chlorine is thereby converted into muriatic acid, and its compounds into muriates; but whether the oxygen unites directly with the colouring matter as a whole, or forming a peculiar compound, or, combining with the hydrogen of the vegetable principle, reduces it to a soluble state, cannot be determined till we know more of the nature and constitution of the vegetable principle, or principles, which it is the object of the bleaching art to extract.

We are equally in the dark as to the agency of the acids in bleaching. The earlier bleachers of the modern school direct, in the bleaching of cotton fabrics, the use of the vitriolic sours only as a finishing process, to dissolve out any iron which might be deposited by the previous buckings in potash; such is the opinion of Berthollet and Hume; for linen they do, indeed, recommend three or four applications. That the solution of any oxide of iron deposited on the cloth is one effect of the sours,

* This article was introduced into the bleaching art in Ireland some years ago, at the suggestion, I believe, originally of Mr. Kirwan. It is a very powerful solvent of the colouring matter of linen, but was found to be an unsafe application on a large scale, and has now fallen into disuse.

cannot be doubted: in proof of this, Berthollet informs us, (and every scientific bleacher is, perhaps, aware of the fact from experiment, "that the prussiate of potash occasions, after some time, in the sour a blue precipitate; but," the same writer continues, "is the action of the acid confined to the above use? if it be, why repeat this operation four times, and apply a ley between each of them, while for cotton equally exposed to be stained by the ferruginous deposite a single sour is sufficient?" The suspicion implied in this interrogatory, that the most important agency of the acid in the bleaching art was not yet understood, would have been still stronger had the writer known at that period the decided advantage derivable from earlier and repeated use of this agent in the bleaching even of cotton. The acid of the bleaching sours does not appear to suffer decomposition. It is not improbable but its agency may be exerted in changing the relations of the elements of water to the other ingredients of the colouring matter, somewhat analogous to the action of diluted sulphuric acid on starch and some other organic compounds, and thereby rendering it more soluble in the other liquids employed.

The best arrangements for drying cloths are noticed under the head of "drying rooms" in this work.

To cover a tendency in bleached cloths to assume a slight yellowish tint in drying, it is usual to tinge the last rinsing water with a minute quantity of some blue material, and this process is called the blueing. The sulphate of indigo is sometimes used for this purpose, though minutely ground indigo diffused in the water is generally preferred. But the most delicate shade is imparted to the cloth by the use of finely ground smalt, diffused through the water in the usual manner of applying the solid indigo.

The remaining operations of calendering, folding, pressing, &c., to fit the goods for market, are strictly mechanical; and do not come within the province of this work.]

[CALICO PRINTING

Is the art of topical dyeing. In treating of it I shall endeavour to adopt such an arrangement as shall appear most conducive to the instruction of a person tolerably well versed in the principles of chemical science; having access to the ordinary mechanical arrangements of a calico printery, but little or no acquaintance with the peculiar processes of the art.

Madder Dyeing.

Madder belongs to that class of drugs, the colouring matter of which cannot be permanently fixed upon cloth without the intervention of some metallic or earthy substance, capable of forming a ternary compound with colouring matter and the cloth; such colouring principles have been denominated by Dr. Bancroft *adjective* colours, in contradistinction from those colours which may be made to unite permanently with the fabric without the intervention of a third substance, and which he calls substantive colours. The metallic or earthy bases employed in *fixing* vegetable colours, are called *mordants*.

There are but two mordants, or rather but two classes of mordants now employed in fixing the madder dye, the salts of alumine and iron, which, either singly or combined, are capable of producing a great variety of colours.

Of the Aceto-Sulphate of Alumine, or Red Liquor of the Calico Printers.

Pure alumine has a strong attraction for the colouring matter of madder, (as well as for that of various other dye-stuffs;) but being insoluble in water, it is necessary to employ it in union with an acid in the form of a neutral, or rather a super-acid, salt dissolved in water; the cloth is first either soaked or printed in parts with this solution, and afterwards dyed in the madder. In ordinary dyeing, where the cloth is not necessarily dried between the application of the mordant and the dyeing process, (that is, in what the dyers call *fancy dyeing* on cotton,) common alum (the super-sulphate of alumine and potash) is employed; but in topical dyeing, where only parts of the fabric are impressed with the mordant, and where the cloth is unavoidably dried and exposed to a warm temperature between these two operations, the pure sulphate (as well as the muriate and nitrate) of this earth is inadmissible, on account of its tendency to crystallize before the cloth becomes thoroughly impregnated with its base. The acetate of alumine is not a crystallizable salt; and is, therefore, generally employed in calico printing.

As native alumine is not soluble in the acetic acid by direct means, the red mordant is obtained by double decomposition; for this purpose

Take 100 gallons of water;

300 lbs. of alum;

168 lbs. of sugar of lead;

30 oz. of carbonate of lime (whiting) in fine powder.

Dissolve the alum in the water by heat; then add the whiting

by degrees, and, last of all, the sugar of lead, and stir a few minutes; the decomposition is almost instantaneous; the sulphuric acid of the alum combines with the oxide of lead of the acetate of lead, forming an insoluble sulphate, and the acetic acid of the acetate of lead unites with the alumine of the alum, forming an acetate of alumine, which remains in solution. The whiting is added to neutralize a part of the excess of acid of the alum. As soon as the sulphates of lead and lime have subsided, the clear liquor may be decanted; it will have a specific gravity at 60° Fahr. of 1.090 or 18° on Tweedale's Hydrometer. Before the addition of the whiting its specific gravity is 1.095 or 19° T., (that is, at 60° Fahr.,) owing to the presence of sulphuric acid. Although three ounces (to the gallon) of carbonate of lime have been added, there is still a considerable excess of acid; there is as much, in fact, as would combine with four and a half ounces more to the gallon; for each pound of alum will combine with two and a half ounces of carbonate of lime without parting with an atom of its alumine: it is advisable, however, to retain this excess of acid, otherwise the colours will not be so bright, and the liquor will become stiff when boiling hot; this last circumstance is owing to a singular property, first pointed out by Gay Lussac, that the solution of acetate of alumine possesses the power of precipitating a part of its base when hot, and redissolving it again when cold. The excess of acid prevents this effect. There is also in this mordant a very considerable excess of alum; one pound of sugar of lead will decompose only three-fourths of a pound of alum, and yet we have but $2\frac{2}{10}$ lbs. of sugar of lead to 3 lbs. of alum. This mordant is, in fact, an aceto-sulphate of alumine. An excess of alum is, however, found useful, for the same reason that an excess of acid is. It has always been objected to by theoretical chemists, and as invariably insisted upon by the calico printers; there is a considerable diversity of opinion as to the exact proportions of sugar of lead and alum, but all agree in using an excess of the latter. The smallest proportion of sugar of lead to the alum, recommended by good printers,* is 1 to 2, and the largest proportion $2\frac{1}{2}$ to 3; within this range we meet with every possible proportion. The proportions given above are such as I have found to answer on a most extensive scale, but will not undertake to say that they are the best that could be. It has been objected to so large an excess of alum; that it imparts to the liquor a bad thickening property with flour, that of being apt to separate from the liquor. This difficulty, however, I

* Berthollet directs 1 to 3 in his work on dyeing, but the best English calico printers rarely use these proportions.

have ascertained to be more dependent upon the excess of acid of the alum than to the salt itself, and have accordingly used and directed rather a larger quantity of carbonate of lime than is usual. It is said that an ounce or two of common salt, added to each gallon of the liquor, will obviate this objection; but I have never had occasion to use it.

A cheaper method of obtaining the red mordant is to substitute the acetate of lime for the sugar of lead in the double decomposition with alum.

The Acetate, or Pyrolignite of Lime

Is prepared by saturating the impure acetic, or pyroligneous acid with quick lime. One hundred gallons of the impure pyroligneous acid of a specific gravity of 7° T. will require for perfect neutralization from 70 to 75 lbs. of lime. Slake 60 lbs. of lime with a portion of the acid, in the usual way of slaking lime with water,* and afterwards add the remainder of the acid, and stir frequently for two days. If the acid is not all neutralized, which may be ascertained by the taste with sufficient precision, continue to add lime in small quantities till it is so. If the lime is new and quick, a scum of charred tar will rise upon the surface of the liquor on standing a day or two, from a half to one inch in thickness; about 75 gallons of clear liquor may be obtained from the above quantities of lime and acid, which should be carefully decanted from the muddy deposit of lime and tar at the bottom. The solution when finished should have a specific gravity of 16 or 17° T., if it mark higher than 16° , it may be reduced to 16° by dilution with water. If the lime liquor be used of a specific gravity of 19 or 20° T., in the decomposition of alum, the sulphate of lime will not precipitate well, and it is almost impossible to obtain a clear solution without large dilution with water, which of course will reduce the standard mordant too low. To prepare the aceto-sulphate of alumine from this liquor,

Take 100 gallons solution of pyrolignite of lime at 16° T.;
300 lbs. of alum.

Dissolve the alum by heat in the pyrolignite of lime; skim the top, and let the sulphate of lime subside; when cold decant the clear liquor. It will have a specific gravity of 22° T. at 60° Fahr. On standing a few days a thick scum of tar will rise,

* It might be objected to slaking the lime with the red liquor, on the ground that the heat generated will evaporate, if it do not decompose a portion of the acetic acid, (which is not improbable;) but a clearer liquor (more free from tar) is obtained by this process than if lime were used in the state of a hydrate.

which must be skimmed off, and the specific gravity will then be somewhat lower,—at about 21° T.

The precipitated sulphate should, in this case, as well as in the decomposition of the acetate of lead, be carefully washed by adding to it a quantity of water equal to one-third or one-half the quantity employed in the first instance; a weak solution of the mordant may in this way be obtained, which will always come in use for the lighter shades of colour, and is a clear saving of what is not unfrequently thrown away by negligent colour mixers.

In preparing the aceto-sulphate of alumine, by either of the foregoing methods, care should be taken that the material be as free as possible from iron. The white crystallized sugar of lead should be preferred. There are considerable differences in the quality of alum met with in our market. The comparative purity, in this respect, of the different samples may be ascertained with tolerable accuracy by the depth of the colour of precipitates produced by the solution of the ferro-prussiate of iron, or tincture of nut galls, on solutions of the same strength. A sufficient test of the freedom of lime from iron is its whiteness. The pyroligneous acid, from the universal practice of distilling it from iron vessels, always contains more or less iron, and hence the reds and yellows dyed on the mordant, prepared from it, are never so bright as from that prepared from the best sugar of lead. We occasionally meet with an impure brown sugar of lead in the market, prepared from litharge and the pyroligneous acid, which is not at all superior to the pyrolignate of lime for this purpose, and which yet bears a price nearly equal to that of the purest article. Various attempts have been made to procure a purer acetic acid for this purpose from the fermentation of malt, from diluted alcohol, &c.; but they have all been found to be either more expensive than the acetate of lead or lime, or attended with some other disadvantage, which has prevented their successful introduction into general use.

The *red liquor* prepared from sugar of lead affords a brighter colour both with madder and quercitron bark, than that from the acetate of lime, and is therefore generally employed where very bright and delicate colours are required; particularly for pinks, pale reds, and yellows. For deep full reds the liquor from the acetate of lime is more generally used; and for all those colours in which the red mordant is mixed with iron liquor, it is equally good as that from the sugar of lead.

The red mordant from pyrolignate of lime will afford a much brighter red, if the cloth be dyed up immediately after it is printed, before the acetate of iron, with which this mordant is contaminated, becomes decomposed and fixed upon the cloth.

As there are no distinctive appellations for this mordant, when prepared in these two ways, I shall, in the remaining formulas, distinguish them, to save circumlocution, by the terms *old red* and *new red*; that prepared from sugar of lead and alum having been longest in use, I shall denominate *old red*, and that from pyrolignite of lime and alum, *new red*, liquor, or mordant.

The *old red* mordant at 18° T., and the *new red* mordant at 21°, may be considered as standard liquors, capable of affording the deepest red with madder, and yellow with the quercitron bark. For the lighter shades of colour they are diluted with one, two, three, four, or five parts of water, according to the shade required and denominated No. 1, 2, 3, 4, or 5 red, according to the number of parts of water added. It is seldom that a lighter shade of red is wanted than will be produced by five waters to one of the standard liquor.

Sighting for the Aluminous Mordant.

To enable the printer to see the progress of his work, and to judge of the impression he is making, it is usual to tinge the mordant with some fugitive colouring matter before it is thickened. It is a convenience, though not absolutely necessary, to have the mordant sightened (as the printers term is,) of the same colour as that of which the calico is intended to be dyed. For red liquor,

Take one gallon of the aluminous mordant (old red is preferable,) and digest for twelve hours on one pound of ground peach wood at a temperature not exceeding 100 Ft., strain and make up the loss of liquor by evaporation with water. Half a pint of this decoction will sighten one gallon of colour for machine printing, and two gallons, if applied by the block. Where a diluted mordant is required, a decoction of peach wood in water may be used, and constitute a part of the water used for dilution.

Thickening for the Aluminous Mordant.

The object of thickening is to prevent the colours from spreading upon the cloth. For this purpose gum Senegal, flour, starch, and British gum, (calcined starch,) are generally employed. Gum imparts to the mordant the best working properties, but its expense forbids its use for common work, according to the opinion of most printers; where, however, it can be obtained of a good quality for 12½ cents *per lb.*, it is as cheap as flour at \$7 per barrel, and particularly for block work; it expends better; the colour it affords is brighter, and there is much less waste than with flour paste; if two pieces of cloth

be examined after they are dyed, the one of which was blocked in the red mordant thickened with gum, and the other with the same mordant thickened with flour, the piece printed in gum colour will be found to show a brighter colour on the face than that thickened with flour, and a poorer colour at the back. The reason of this difference seems to be that the paste separates more readily from the dissolved mordant, and suffers the latter to transude through the cloth, and pass to the back side, leaving the paste upon the front surface; whereas the gum holds the mordant with greater tenacity, does not suffer it to separate so easily from it, and accordingly deposits a larger portion upon the face of the goods.

Standard Gum Red.

Take 10 gallons of Red Liquor (old or new);
55 lbs. Gum Senegal.

Add the gum to the liquor, and let it stand from 12 to 24 hours, without agitation, then stir till dissolved, and strain through a cloth. The solution will have a specific gravity, if the gum be good, of 35 or 36° T. Stir in more red liquor till the specific gravity is 34° T. This mordant is rarely worked so stiff as this, but the printer is allowed to thin it by the addition of more liquor till it have the required consistence. As a strong solution of gum will not undergo spontaneous decomposition, this thickened mordant may be kept for months and perhaps years without injury.

If lighter shades are required, nothing is necessary but to reduce the strength of the "standard gum red" by the addition of one or more parts, as the case may be, of a solution of gum Senegal in water, of the same specific gravity as the gum red.

Standard Paste Red.

Take 1 gallon of standard Red Liquor;
2 lbs. Flour (sifted.)

Add the red liquor by degrees to the flour, and beat it up into a perfect paste; then turn the mixture into a copper boiler, and boil 15 or 20 minutes, stirring all the while to prevent the paste from caking to the bottom and sides of the boiler. Two lbs. of flour is the average quantity required for paste intended to be worked by the engraved cylinder; but some patterns require more and some less. The average quantity for paste to be worked by the block is about 1½ lbs. In either case, if the paste be too stiff, it may be thinned by stirring in a small quantity of the unthickened liquor, but the paste is scarcely so good

as when the right consistence is obtained in the first instance. This paste will not keep well, and in warm weather must be *worked* the day it is prepared, or, at farthest, the day after.

Another (for the roller.)

Take 1 gallon of standard red liquor;
28 oz. of flour;
4 oz. British gum.

Beat up the flour and gum in separate portions of the liquor; then mix, and proceed as in the last case. The British gum is thought by some to improve the working properties of the paste.

Some calico printers make use of equal parts of starch and flour for thickening this mordant; but starch is in no respect better than flour, and treble or quadruple the cost.

The mordant for yellows is the same as for reds, with the exception that it is usual and convenient to sighten the liquor with a decoction of quercitron bark instead of peach wood.

Protacetate of Iron, or Iron Liquor.

This important mordant may be prepared either by the direct union of its component parts, or by double decomposition. The first method is now generally practised, and consists in digesting the crude acetic, or pyroligneous acid, of a specific gravity of 7° T., upon an excess of clean malleable iron, in a state of minute division, till the liquor has acquired a specific gravity of 18° T., at the temperature of 60° Ft., which point must be ascertained by cooling a small quantity dipped from the boiler from time to time, and testing it by the hydrometer. A large cast iron boiler should be employed, and the liquor kept at a temperature not to exceed at any time 150° Ft. If clean wrought iron turnings* be used, and in considerable excess, the process may be completed in from 5 to 7 days. Considerable tar rises during the solution, which should be skimmed off: a still heavier scum will continue to rise after the liquor is cold, and, indeed, for days and months afterwards, a part of which it is better to allow to remain undisturbed, till the liquor is wanted for use, and more particularly if it is exposed to the action of the air in an open cistern.

Some printers prepare this liquor without heat; but the process described is preferable; when the solution is effected with-

* Cast iron and steel, even in the minutest state of division, are nearly insoluble in acetic acid.

out heat, the tar attaches to the surface of the iron, impedes the action of the acid, and renders the process extremely tedious; there is also in the latter case more risk of peroxidizing the iron, particularly if the liquor be much exposed to the air by pumping, or pouring it backwards and forwards from one vessel to another, as erroneously recommended by most writers on this subject, and still practised by many calico printers. After repeating this operation two or three times, the iron becomes so coated with tar, notwithstanding the use of heat, as to make it necessary to remove it, and supply its place with a fresh quantity. It is generally recommended to burn off the tar from the iron by exposing it to the flame of a reverberatory furnace, and use it a second time; but I have not found the practice to answer a good purpose; the tar may, indeed, be dissipated in this way; but the surface of the iron, and in fact the whole of it, if turnings be used, is converted into the black deutoxide, which is perfectly insoluble in acetic acid. It is difficult to obtain wrought iron turnings free from rust; the water used to wet the tool in turning, unless carefully dried off after they are formed, (and which the machinist of course will not attend to,) is sufficient to convert a part of the iron into the peroxide in a very short time, and which forms with the acetic acid a peracetate; a mordant wholly unfit for many, and inferior for any, of the uses of the calico printer. This rust may be readily removed by washing the iron turnings, previous to use, with a very dilute solution of sulphuric acid in water, and afterwards rinsing them in clean water.

From 100 gallons of pyroligneous acid, with the requisite quantity of iron, from 60 to 70 gallons of iron liquor at 18° F. may be obtained. This solution, reduced to 12° F., is sufficiently strong to produce a deep black with madder, and may therefore be regarded as the standard iron liquor, or black mordant.

This mordant may also be obtained by the double decomposition of the acetate of lead, or lime, and the proto-sulphate of iron; for this purpose,

Take 1 gallon of water,
4 lbs. of persulphate of iron, &c.,
2 lbs. of acetate of lead.

Dissolve the sulphate of iron in the water, and then add the sugar of lead; stir the mixture till the decomposition is complete, which is almost instantaneous, if the solution of copperas be hot when the lead is added; when the sulphate of lead has subsided, decant the clear liquor. There remains a considerable excess of undecomposed copperas in this solution.

The acetate of lead is, however, never used for this mordant,

unless as an extemporaneous preparation, where the acetate of lime is not at hand. To prepare the iron mordant from the latter,

Take 75 gallons solution of pyrolignite of lime at 16° T.;
400 lbs. of proto-sulphate of iron (green copperas);
100 gallons of water.

Dissolve the copperas in the water by heat; then add the pyrolignite of lime, and stir well together; when the precipitate has subsided, decant the clear liquor. This liquor at 60° Fahr. will have a specific gravity of 22° T., and reduced to 12° T., by the addition of water, is supposed to have about the same strength as that prepared by the direct solution of iron in the pyroligneous acid of the same hydrometrical strength, and which I have assumed as a standard.

The acetate of iron is preferred to the salts formed by the mineral acids with this metal, for the same reasons that have already been assigned for a preference of the acetate to the sulphate, muriate, and nitrate of alumine.

All the green salts of iron (that is, all those which have the protoxide for their base) have the property of attracting oxygen from the air, precipitating a portion of their base, passing to the highest state of oxygenation, and forming super-acid salts, with the peroxide for their base. Owing to this circumstance, the iron liquor, which is a protacetate, should be excluded from the air as much as possible; but it is difficult to exclude it altogether, and where this mordant is kept on hand for a considerable length of time, as it must often be, I would recommend adding to it, from time to time, small quantities of clean iron turnings, which will detach and combine with the oxygen of the peracetate, restoring it again to the protacetate, and unite with and neutralize the free acid. To prevent too great an accumulation of sediment in the casks or cistern, by these additions of iron, the turnings may be suspended in the liquor by a coarse netting.

No sightening is necessary for the iron mordant, prepared with pyroligneous, when used of the standard strength, as the solution is sufficiently coloured without it; for the diluted liquor, a decoction of logwood (one pound to the gallon) chips must be used. The logwood is preferable in the form of chips, rather than in a ground state, on account of the difficulty in the latter case of obtaining a clear decoction.

Standard Gum Black.

Take 10 gallons of iron liquor at 18° T.;
5 gallons of water;
100 lbs. of gum Senegal.

Dissolve the gum in the water by heat, and when dissolved pour it into the iron liquor, and stir briskly till the mixture is perfect. The colour when cold will mark $36\frac{1}{2}$ or 37° T. Dilute with iron liquor till the mixture have a specific gravity of 34° T. This method is preferable to dissolving the gum directly in the iron liquor at 12° T.

The standard iron liquor, diluted with from one to twelve waters, forms various shades of purple, which are thickened with gum, or flour, as the case may require. The process of thickening iron liquor with flour is the same as with the aluminous mordant already described.*

Mordant for No. 1 Chocolate.

Take equal parts of iron liquor at 12° T., and new red liquor at 22° T.; mix and thicken with flour. The iron liquor should be sightened with logwood.

Mordant for No. 2 Chocolate.

Take 1 part of iron liquor at 12° T.;
2 parts of new red liquor at 22° T.

Mix and thicken as before. The foregoing and intermediate shades are best suited for cylinder patterns; for the block three or four parts of red liquor to one of iron are of frequent use.

Mordant for a Purple.

Take 1 part of iron liquor at 12° T.;
1 part of water, sightened with logwood;
One-tenth part of new red liquor at 22° T.

Mix, thicken, &c. This mordant affords a beautiful shade with madder. The common printers' No. 1 purple is the same as the above, leaving out the red liquor; but the colour is much improved by this addition; this is intended for the machine; for the block lighter shades, but the same relative proportions may be used.

Mordant for a Dark Mulberry.

Take 3 parts of iron liquor at 12° T.;
 $1\frac{1}{2}$ part of new red at 22° T.;
 $1\frac{1}{2}$ part of water sightened with a decoction of logwood.

Thus by varying the strength as well as the relative proportions of the two mordants, an almost infinite variety of shades may be produced.

* It may be well for the colour mixer to know, that boiling over 15 or 20 minutes has a tendency to render the paste too *gummy*.

Mordant for Blue Lavender (for the block.)

Take 10 parts of iron liquor at 12° T.;
1 part of new red at 22° T.;

Mix for a standard; then of this standard take 1 part, and 8, 10, or 12 parts of gum water, according to the shade required.

Mordant for Red Lavender (for the block.)

Take 3 parts of new red at 22° T.;
1 part of iron liquor at 12° T.

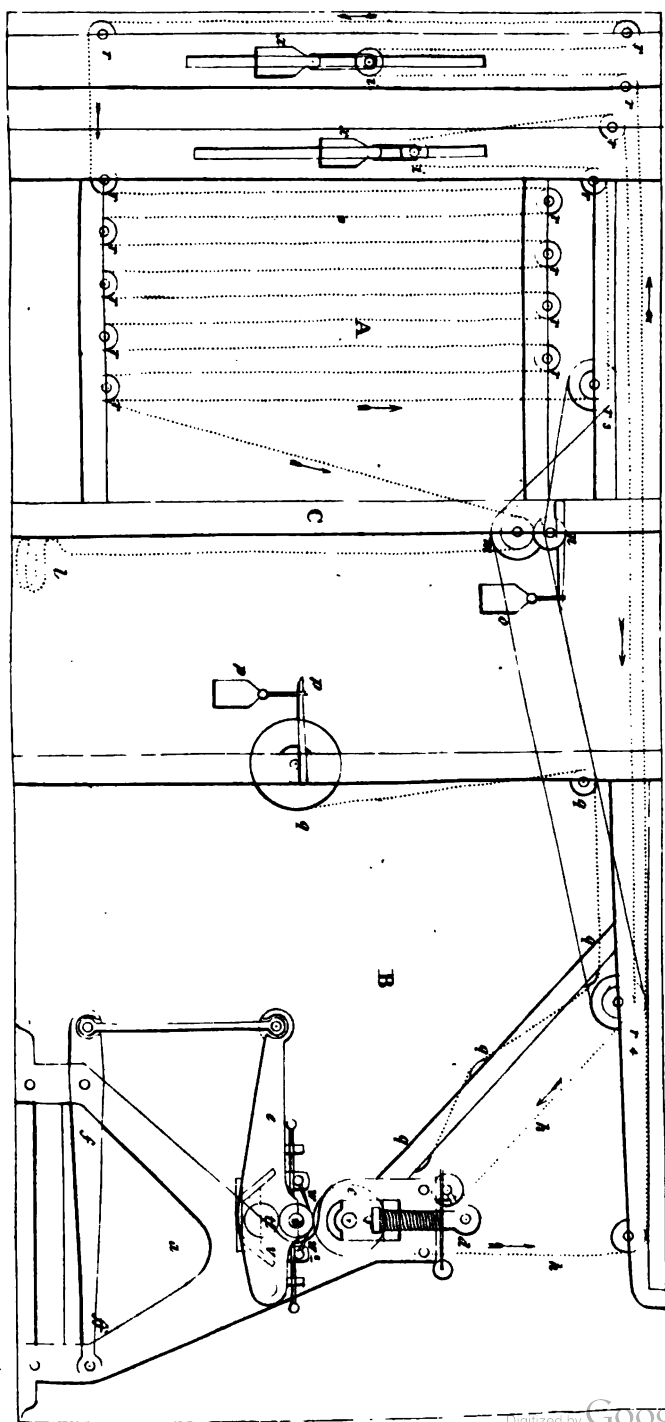
Mix for a standard; then take of this standard 1 part, and 4, 6, or 6 parts of gum water, according to the shades wanted.

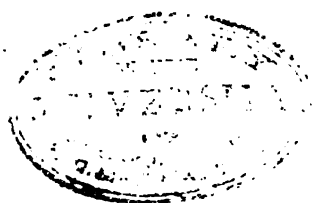
Machine Printing.

Machine printing differs from copper plate engraving in nothing, essentially, except the mechanical arrangements necessary for operating with a cylindrical instead of a flat surface.

Fig. 237 exhibits a vertical section of a machine printing and stoving room, in such a direction as to show an end view of the printing machine and rollers for the distribution of the cloth and machine blanket in the stoving room. *A*, the stoving room; *B*, the machine room, and *C*, the dividing wall between them; *a*, the printing machine. The figure intended to be printed on the calico is engraved upon a hollow copper cylinder, *t*, which is fixed during the operation of printing upon a horizontal iron mandril, or arbor, which revolves with it. Immediately underneath the copper roller or cylinder, and in contact with it is a wooden roller, *tt*, called the furnishing roller, covered with woollen cloth, which revolves with the copper roller; this furnishing roller revolves in a box, *v*, which contains the colour or mordanted paste to be applied to the calico, and is imbedded in it to the dotted line; the view of the colour box should strictly be concealed by the lever *e*, but for illustration is represented as if seen through it. During the revolutions of the copper roller, and the furnishing roller, the under surface of the former is constantly besmeared with the colour or paste; the plane or unengraved surface of the copper roller is afterwards freed of the colour by a thin straight edged plate of steel, *w w*, called the doctor, which rests obliquely upon the copper roller, and scrapes the superfluous colour back into the colour box, leaving the engraved portions of the cylinder filled to a level with the unengraved parts. The white calico intended for printing, is first rolled smoothly upon a small wooden hollow cylinder, which slips upon an iron centre or shaft, and which has small friction levers resting upon its gudgeons, and weighted to prevent the calico from unwinding too easily, and to give a tension and smoothness to the cloth as it enters the machine; *q* shows the roll of calico, and *pp* the lever and weight of one end. From this roller the cloth is conveyed to the machine over the rollers *qqqq*, in order to allow room for the workman to come at the back of the machine; the cloth then passes through the machine between the engraved copper roller and the iron roller *c*, and thence to the stoving room in the direction of the dotted line at *h*. As soon as the end of the piece is passed through the machine, the iron roller, *c*, is pressed firmly down upon the copper roller by the screws at *d* operating upon the steps of its gudgeons; in many of the old machines these screws constitute the only compressing force, but more recently this force is really applied by weighted double levers which affords a constantly operating pressure, and at the same time one that will yield to slight inequalities in the thickness of the cloth or blankets interposed between the two rollers; *ef* are the dou-

Fig. 137.





ble levers which are situated just within the sides or cheeks of the machine; but, for convenience of description, are represented as though seen through the frame or sides of the machine; the weight is applied at *ff*, and this combined leverage is brought to operate upon the mandril *b*, pressing the copper roller with great force upwards against the large iron roller *c*. I have said that after the calico is passed through the machine, the iron roller is pressed down upon the copper roller; but such is the force with which the machine operates, that were there nothing but the calico interposed between the two metallic rollers, the calico would be cut asunder in the operation, and the engraving ruined, perhaps, in a single revolution of the copper roller; to prevent this the iron roller is previously wound round with from 20 to 30 thicknesses of a strong twilled woollen cloth, which is called by the machine printer the *lapping*, which protects both the calico and the copper roller from injury, and also serves another important purpose, that of pressing, in consequence of its elastic property, the calico into the engraved figure, and thereby producing a clearness and fulness of impression, which it would otherwise be impossible to effect. It will be observed, that the furnishing roller below, and the iron roller above the copper roller, are both driven by the latter by the mere force of friction, and that through them motion is given to all other parts of the machine; the cloth is unwound from the roller *q*, and carried through the machine, the copper roller is successively supplied with colours, and its plane surface cleared of superfluous mordant, and the impression produced on the cloth without any essential aid from the printer, except to supply the colour box with the paste, and see to the correct performance of the machine: *w 2* is a second doctor, placed in front of the machine, (and opposite the *cleaning* doctor, so called,) the object of which is to detach from the copper roller small bits of lint which it contracts from the cloth, and thereby to prevent their mixing with the paste, and form an obstacle to the correct performance of the cleaning doctor, by getting between it and the roller.

The doctors have a lateral motion of about three-quarters of an inch on the roller, the object of which is to prevent the unequal wear of the roller in consequence of any unequal hardness in the roller: in consequence of this lateral motion, any given point on the edge of the roller describes a waving or laterally undulating line, instead of a circular course round it. Then the colour or paste contains matters that act on steel, as the salts of copper in the reserve pastes and other similar articles, brass or other composition doctors are used in their stead.

Such are the arrangements *essential* to the mere act of producing an impression with the printing machine for the moment; but, in order to a sustained operation of it, some important appendages are necessary, which remain to be described. From the difficulty of entering the cloth in the machine, so that it shall constantly cover the same space on the copper roller, as well as from the variable width of the pieces, which produces the same result, it is necessary to furnish a wider space on the engraved roller than the cloth will actually cover, and, in consequence of this, were there nothing interposed to prevent it, the lapping of the iron roller without the margin of the calico would soon become clogged with colour, and would constantly endanger the calico by spreading upon it on the one side or the other, and render it impossible to proceed without spoiling the work, for it must be recollected that every impression of the mordant, whether accidentally or purposely made, will produce a corresponding colour in dyeing in the madder bath, (on the supposition of printing for this style of work.) To obviate this difficulty an *endless* blanket (so called) of firm woollen cloth, whose circumference shall be about fifty yards, is made to pass through the machine between the calico and the lapping of the iron roller; the two parts of the blanket, as it goes to and leaves the machine, is shown in the dotted lines *h h*, and its course as propelled, or rather drawn by the machine, is indicated by arrows; taking the ascending part, the eye can easily trace it through the partition wall, *C*, into the stoving room, and thence over numerous rollers till it arrives at the back of the machine, where it joins the calico again, and passes on with it through the stoving room to the last of the

rollers designated by *r*, where the calico leaves the blanket, and arrives by *s* shorter course, *k*, through the drawing rollers, *n m*, to the machine room, and falls down upon the floor at *l*: the object of this arrangement is obviously to dry the paste both on the calico and on the blanket; in the first case, to prevent the mordant, by touching the unprinted parts of the cloth, from soiling it, and to fix it by the evaporation of the moisture, and, perhaps, a portion of its acid more intimately upon the cloth; and, in the second place, to dry the paste upon the blanket to prevent its attaching to the calico; the blanket should be from four to six inches wider than the calico, or wide enough to cover the whole of the engraved part of the roller: *ii* are the tightening rollers, the gudgeons of which slide up and down in the mortises of two upright posts or standards; these rollers are weighted at each end, *x x*, sufficiently to keep the blanket in a state of equable tension, and to take up what it may stretch in length in the operation of printing: it will be observed, that one of these tightening rollers is applied to the part of the blanket soon after its entrance into the chamber, and the other to the part about to return from it; the latter roller only is usually employed, but there is a particular advantage in having two, as the slackness of the blanket, which is frequently troublesome to the printer, generally occurs immediately before, or immediately after it enters the machine, and cannot easily be kept in a sufficient state of tension by one tightening roller only placed at any part of the circuit, which the blanket describes. All the rollers and other fixtures in the stoving room should be fire proof; the rollers should be constructed of sheet copper, with iron gudgeons, and the room itself should have nothing in its structure of a combustible nature. The frame work which supports the rollers is represented unnecessarily heavy for iron, but in all other respects the drawing is correct. The drawing rollers, *n m*, are carried by a belt running from a pulley attached to *m*, and another attached to *r 3*, or *r 4*, at the pleasure or convenience of the printer. The roller *n* is pressed upon the roller *m* by levers, resting upon each gudgeon and weighted at *a*.

It is not often that so great a length of blanket is absolutely necessary, and in most cases (that is, in light and medium figures) two pairs of the rollers, designated by *r*, may be dispensed with. Some printers prefer a second set of light rollers for the calico to run upon, so as to keep it separated from the blanket through its whole course after it leaves the machine; this admits the air more freely to the back as well as the face side of the blanket, and expedites the drying process.

The best method of treating the stoving room is by horizontal brick flues with cast iron tops,—the same in all respects as recommended by the writer for drying rooms under that article in this work.

The art of printing by the machine is purely mechanical, and any intelligent machinist may acquire a competent knowledge of it in a short time.

The gearing for driving the machine is omitted in the plate to avoid complicating the more essential, or rather the more peculiar parts of the machine; the skilful machinist will find no difficulty in applying the common principles of his art to this object. It is usual to gear the machine for two motions. The slowest speed should be sufficient to print a piece of twenty-eight yards in four minutes, and the fastest in two and a half minutes.

The entire cost of a machine like the one represented, including the gearing and fixtures in the stoving room, may be about eight hundred dollars.

Padding.

The object of padding is to cover the calico uniformly with a mordant preparatory either to printing a *discharge* upon it previously to dyeing, or a secondary colour, or discharge, or both, after dyeing. If this were attempted by dipping the cloth in the liquid mordant, squeezing and drying in the usual way of drying wet cloth, by hanging in the air, the larger por-

tions of the mordant would subside into the most dependent parts of the cloth before its solvent were evaporated, and cause a very unequal deposition of the mordant upon the fabric, which of course would be followed by corresponding variations in the shade of colour after dyeing. To obviate this difficulty, the cloth is passed first through the liquid mordant, then squeezed hard between two metallic rollers, and dried in the stoving room as speedily as possible, consistently with the nature of the mordant and the safety of the cloth. The machine for this purpose is quite similar to the single coloured printing machine just described, with the exception of leaving out the *doctors* and the *furnishing roller*, and substituting for the latter a small wooden roller, which is placed near the bottom of the box in which the liquid for padding is put, and around which the cloth is passed before it enters between the rollers: indeed, in small works it is not unusual to pad with the single coloured machine. In this operation both rollers are plane, and both are lapped with cloth precisely in the manner in which the iron roller is lapped for printing, only fewer turns are necessary. Some prefer cotton to woollen cloth for lapping; for padding for light shades of colour, I prefer the former, but for the deepest shades the latter is preferable, owing to its greater elasticity and its superior capacity for the liquid, by which calico is more fully impregnated with the colour. The quantity of mordant left in the cloth depends also, in some measure, upon the pressure under which the rollers are worked. The cloth is dried after padding, in the same manner as after printing by the machine; owing, however, to the greater quantity of moisture to be evaporated, the temperature must be somewhat higher, and the time of exposure somewhat longer than in printing. It is better, also, if the rollers be so arranged in the stoving room, that the calico in passing from one roller to another shall run in a horizontal instead of a perpendicular direction as represented in fig. 237. This arrangement is in no respect less convenient for drying after machine printing.

When padded cloth is dyed up, the colour will be a shade deeper on the side of the calico which runs in contact with the lower roller, or rather on the underside of the cloth, as it passes from the machine to the stoving room, owing to the partial subsidence of the liquid to that surface before the liquid part of the mordant is evaporated.

In the foregoing remarks on machine printing and padding, and in the plate explanatory of the former, I have departed from the plan proposed at the commencement of this article on calico printing, which was to treat only of the chemical and not of the mechanical part of the art, but the processes of machine

printing and padding are of such cardinal importance in the art, and so often referred to in the following pages, as to render this short digression from the main purpose and plan of the treatise, almost indispensable; but, not to deviate farther from my principal object, the reader is referred for a plate and description of the padding machine to Dr. Ure's Translation of Berthollet's Elements of Dyeing and Bleaching.

Influence of Temperature on the Aluminous Mordant.

I have already alluded to a singular property of the solution of the acetate of alumine in water,—that of precipitating a part of its base at a high temperature, and redissolving it again when cold; owing to this property this mordant should be printed at as low a temperature as possible; the reason is obvious, the more gradually and slowly the cloth is dried, the more perfectly will the mordant have penetrated the fabric before the liquid, which holds the aluminous base in solution, shall have been dissipated, and even before any portion of the base shall have been precipitated in an insoluble state from its proper union with its acid. I think it may be asserted as an axiom in the art, that the lower the temperature at which the printers' aluminous mordant is applied, and dried, the brighter will be the colour on dyeing in madder; a very marked difference is observable between two pieces of calico printed with the same mordant, the one dried at the temperature of 150°, and the other 250° Fahr. I would recommend in no case, in printing or padding with this mordant, to expose the goods to a higher temperature than 150° or 180° Fahr. at the most; and, where the figure is light, and will admit of it, a still lower temperature is desirable.

Ageing Printed Goods.

After the cloth has been printed with either the aluminous or iron mordant, it is usual to hang them up exposed to the action of the air for a few days before they are carried to the dye-house, and this process is termed by the workmen *ageing*. Goods printed with the aluminous mordant are generally *aged* three or four, and those with the iron mordant from six to eight, or even ten days. The utility of this practice on cloths, printed with the first mordant, is, at least, questionable. I have never been able to distinguish any difference in the result, whether the cloth was dyed immediately after printing or after an exposure to the air. The theory deduced from the experiments of Thenard and Roard * is, that after printing a portion of the acetic acid

* Vide note B to page 73, vol. i. of Ure's Translation of Berthollet's work on Dyeing.

escapes from the aluminous salt on exposure to the air, and that the remainder of the acid forms with the alumine a sub-salt with excess of base, which, being less soluble in water, is not so liable to wash out in the dyeing process before the alumine is fixed by a chemical union with the colouring particles of the madder. That a portion of the acetic acid evaporates, or flies off from the mordant after printing, is abundantly established by the observation of every calico printer, and it is not improbable that a more careful examination than I have given to this subject, may establish the justness of the theory to some small extent; but the learner may be assured that, practically, it may be altogether disregarded without loss.

With regard to the iron mordant this process is of great utility and importance. If cloth be dyed up in madder immediately after printing with the mordant for black, we obtain a purple scarcely equal to that produced by equal parts of the standard mordant and water, and which has been exposed a week to the air. The acetate of iron when printed upon cloth appears to undergo a partial decomposition, an absorption of air takes place, converting the protoxide into a peroxide, and precipitating it upon the cloth, and a part of the acid escapes in a volatile form. The remaining portion of the acid probably remains in the fabric united with a part of the iron as a peracetate. It is a good rule to allow all goods printed with the iron mordant to age one week; the change, which follows after that period, is very gradual, and, indeed, scarcely appreciable. The lighter shades of colour produced by the iron mordant, and also those shades of colour, into the composition of which the iron mordant enters, may be dyed up in less time, and, in fact, without any ageing, provided the iron be increased in quantity equal to the difference produced in the depth of colour by the usual exposure to the air: in other words, the depth of colour, to a certain extent, is, so far as the iron mordant is concerned, in the compound ratio of the strength (concentration) of the mordant, and the time it has been exposed to the air. It is, however, always a safer course to mix all colours containing this mordant on the supposition of a week's ageing; for it is frequently impossible, in a large work in particular, to dye the printed goods on the very day required by this practice, and a single day's difference in age will make a very perceptible difference in the shade of colour. It is the opinion of some printers that purples are brighter when the printed goods are hanged in a cool room; that is, in a room not artificially heated, though the more common practice of printers has been to hang in rooms heated to 80° or 85° Fahr. The decomposition of the acetate of iron and the oxidation of the metal is more rapid at a high than at a low

temperature; but I have never been able to detect any other difference of effect. A dry atmosphere is, however, of the utmost importance, both as it respects the iron and the aluminous mordant, and more particularly the former, to prevent the colours from spreading. In lowery wet weather, artificial heat is indispensable. For the same reason, great caution ought always to be used that the cloth is perfectly dry before printing; if it be damp the impression will appear much more full on some parts than on others after dyeing, and exhibit a clouded appearance; the colour will spread most upon those parts which are most damp. This uneven appearance is similar to, and not unfrequently confounded with, that produced by uneven *lapping* of the *table roller* of the printing machine, and the machine printer is sometimes blamed wrongfully. The two cases may generally be distinguished from each other by observing that, where the unevenness is owing to uneven *lapping*, the dark and light spots repeat at regular intervals, but where it is attributable to dampness, no such repetition is observable. The effects of a damp cloth is the same on the block as the cylinder work.

The Dunging.

This operation consists in passing the printed calico, after it has received sufficient *age*, through a hot solution or mixture of cow dung in water, and washing the goods intermediately. It is one of the most important in calico printing, requiring great care and judgment to accommodate it to constantly varying circumstances. Goods are more frequently injured in this than in any other stage of the art; and errors committed here are often the source of miscarriages, which are unsuspectingly attributed to the colour mixer, the machine printer, the madder dyer, and almost every thing but the true cause.

The prime object and effect of this operation is to prevent the printed mordant from spreading in the subsequent dyeing bath, and thereby producing a colour where none was intended. The theory of the operation is not well understood, and has been variously explained by different writers; some attribute to the dung a mechanical effect merely, that of entangling and enveloping the loose parts of the mordant, and preventing their attachment to the unmordanted parts of the cloth; others have ascribed to the dung the chemical property of neutralizing the action of the superfluous and uncombined mordant; others, again, attribute to it an effect analogous to that of oil in the *Turkey Red* process, which is supposed to form a ternary combination with the cloth and the colouring particles of the madder. The latter is the opinion of Dr. Bancroft, and it accords best with my own observation. From repeated experiments, I can affirm with

confidence that the operation of the dung is not limited merely to the single effect of neutralizing the uncombined mordant. It certainly does, where performed under the most favourable circumstances, exalt the madder colours; the utility of it is not confined to preserving the white grounds in *topical* dyeing; it is highly beneficial on goods that have been *paddled*; that is, wholly covered with the iron or aluminous mordant, or with a mixture of both, where there is no white ground to protect. A very marked difference will be observed between the depth and beauty of two pieces previously soaked in the aluminous mordant, the one of which has been subjected to the usual dunging process, and the other not, and both dyed in the same madder bath; the dunged piece will show a decided superiority. A hot water bath will, in some cases, answer in a degree the purposes of the dung bath on the iron mordant, but its effects on the aluminous mordant are positively injurious. It cannot be denied, however, that the primary object of the dunging operation is, in most cases, to preserve the ground from contamination, and that in securing this object we are frequently under the necessity of employing a temperature that more than counterbalances the benefit to be derived from the *specific* action of the dung.

The success of this operation depends a good deal upon the manner in which the goods are *entered* into the dung liquor; if the cloth enter in folds, or one part of the face side of the cloth be allowed to touch another part at the moment of entering the liquor, the work is sure to be spoiled; or, if a part that has entered the liquor, and become wetted, be suddenly withdrawn, the colour will be liable to be uneven, and the whites bad. To obviate these difficulties, the *fly winch* is now always used for the first dunging, by which the cloth is made to pass evenly over a number of wooden rollers attached to a frame, which is immersed in the dung liquor; the printed cloth is rolled evenly upon a hollow cylinder, which is slipped upon an iron shaft at the entrance of the cistern, and to which a friction lever is attached to prevent its unwinding of itself; at the other end of the cistern are two wooden *drawing rollers*, to the under one of which a pulley is attached, by means of which the power is applied to draw the cloth through the cistern. The number of rollers, and speed, should be so adjusted that the cloth may be exposed to the action of the liquor about two minutes. From the fly dung cistern, the goods are dropped into a cistern of cold water, where they are partially cleansed, and thence to the dash wheel, in which they are thoroughly washed; they are then dunged a second time, by simply winding them in a common cistern containing the mixture,—rinsed in clean water, *edged up*, (that is, pulled over from end to end by one selvage,

in order to shake out the folds,) and washed again in the dash wheel. If the work be heavy, (that is, if the quantity of the mordant be considerable, as in heavy block work,) it is frequently advisable to repeat a third time the drying, and rinsing, and washing course.

The quantity of dung required depends very much upon the amount of printed surface, and the strength of the mordant. For common *machine* work, 10 bushels to every 100 pieces will be found sufficient for each dunging;—for heavy blotches,* 15 bushels, and where a larger quantity is required it is better to dung a third time with these last quantities. A calico printery, designed to turn off 300 pieces of madder work per day, will require the dung of 100 cows. The average quantity produced by a common sized cow is one bushel per day. The freezing of dung does not appear to injure its qualities for the purposes of the calico printer; neither does there appear to be any essential difference between that which is recently laid and that which has been kept in heaps 10 or 15 days in warm weather; how long it will retain its useful properties I am unable to say.

The temperature of the dung bath is a matter of great importance to the success of the operation. For madder reds and pinks the fly dung cistern should not exceed 160° Fahr., nor the 2d (and 3d, if used,) 140°; too high a temperature impoverishes the reds. This effect is not attributable to the cow dung, but to the solvent power of the water: it appears from the interesting experiments of Thenard and Roard, on the effects of several mordants on vegetable and animal substances, and among them of alum and the acetate of alumine, (vide note B, page 73, vol. i. to Ure's Translation of Berthollet's Elements of Dyeing,) "That in aluming all vegetable and animal substances, it is not the alumine which combines with them, but the entire alum;" that from cloth thus impregnated, it is easy by washings in water to dissolve out the alum entirely, and recover it from the solution in the crystalline state; "that the acetate of alumine combines also in its entire state with silk, wool, cotton, and thread; that this compound retains its acid but feebly, and loses a portion of it by simple exposure to the air; and that it is then changed into acid acetate of alumine, which may be dissolved out by water, and into alumine, which remains upon the stuffs." The object, therefore, is to dung cloths printed with the aluminous mordant at as low a temperature as possible consistent with the attainment of the specific

* This term is applied to heavy block work where the figure covers a considerable portion of the surface of the cloth. Smaller figures are called *pages*.

object of this process. Another effect of a higher temperature than that directed is to sadden the colour of reds and pinks; this effect is most probably owing to the union of the mordant with some colouring principle in the dung itself.

Chocolates and purples may be dunged the first time at 170° or 175°, and the 2d and 3d at 160° or 165°, and blacks at or near a boiling heat. Reds, pinks, and light colours should never be dunged after blacks, purples, or any colour containing the iron mordant, without changing the liquor and thoroughly cleansing the cistern; the reverse, however, may be practised. Where there is a variety of work in hand, the usual course is to dung the reds and pinks first in the morning, then to replenish the cistern with dung without drawing off the liquor, and dung the dark colours. Care should be taken at the commencing of the dunging, that the cow dung be thoroughly beat up and mixed with the water, and the cistern should be stirred up from the bottom frequently during the operation. When the useful properties of the dung are exhausted, the liquor will exhibit a curdled appearance upon the surface, which cannot easily be mistaken. No bad effect can result from using too much dung. The dung cisterns should be emptied of their contents at least once a day, and well cleansed, otherwise it will be impossible to preserve the whites.

If the dunging be conducted at too low a temperature, or too rapidly, the mordant will *start*, as the workmen's phrase is, and run into the whites, but the evil will not be discovered till the goods are dyed; a lesser degree of the same evil is an unusual *fulness* of the impression, which may be mistaken for a similar appearance produced by printing with too thin a paste, or by *ageing* in a damp atmosphere; it may, however, be distinguished from either of the two last effects by observing that, where the starting, or spreading, is owing to imperfect dunging, the defect will be most marked in the heavier parts of the pattern, whereas, in the other cases, the whole figure will partake of the defect. Printers may often skilfully avail themselves of this process to remedy the mistakes of the machine printer; if the impression be too *full* the cloth should be dunged at a higher temperature than directed above; if the printing be too *bare*, the defect may be obviated to a considerable extent by dunging at a lower heat, which will allow the mordant to spread a little. Another effect of imperfect dunging, is a freckled and uneven appearance on the heaviest parts of a pattern; sometimes a shaded stripe will appear lightest where the engraving was actually deepest, and where, of course, the greatest quantity of mordant has been applied; again, we sometimes observe in blocked work a lighter shade at the joining of the blocks, where there has, in

fact, been a lapping of the impression, and where, other things equal, we should expect the deepest shade of colour. The reason of these effects is obvious,—the dung liquor not having penetrated through the paste, where it is applied in the greatest quantity, less of the mordant is fixed upon the cloth than on the lighter parts of the pattern, and not being fixed, is dissolved out in the dyeing process.

Maddering.

After the calico has been dunged and washed the last time, they are ready for the madder dye, and the sooner they are put in the better, though no injury will result from lying in moderate sized heaps for thirty-six hours, unless from fermentation during the extreme heat of summer, in which case they will keep better in a cistern of cold water.

The exact form, or size of a cistern, or copper for madder dyeing is of no importance. A cistern $5\frac{1}{2}$ feet long, $3\frac{1}{2}$ feet deep, and $3\frac{1}{2}$ feet wide, which is, perhaps, the most convenient form, will dye 10 pieces at a time, and may be filled about one-third full of water; into this break the madder, (which I suppose to be the ground madder,) and introduce the goods, connecting every two pieces (at both ends if the winches are worked by power, but only at one end, if worked by hand,) in the usual way over the winch. As soon as the goods are entered, the winching process should commence, and be continued without intermission till the dyeing is completed. The heat should be applied the moment the goods are put into the copper,* and gradually raised till the boiling temperature is attained. The dyeing may be completed in one, two, three, or more hours, at the pleasure of the operator; but the more gradually the heat is raised, and the more time is occupied in the dyeing, the deeper and brighter will be the colour produced; this remark is perhaps applicable in a degree to all madder colours, but more particularly to reds. Madder appears to contain two distinct colouring principles; a *bright red*, which is the part which is alone valuable for the dyers' uses, and a *brownish yellow* matter, called by the French *fauve*, which it is the especial object of the dyer to avoid; both of these colouring matters have an attraction for the aluminous mordant, and, of course, both have a tendency to unite with the fabric in the process of dyeing; but, fortunately, their habitudes are sufficiently different to enable the dyer to

* The direction in Berthollet's Elements of the Art of Dyeing, to mix the madder with water at a boiling temperature or "hot," (which I suppose means the same thing,) is altogether at variance with the views of the best practical dyers at the present day.—Vide Ure's Trans. vol. ii. p. 116.

separate them in a considerable degree in the common operation of dyeing; the yellow matter is not so soluble in water as the red at a low temperature; by using, therefore, a little excess of madder, and raising the heat of the dyeing bath very gradually, the mordant may be mostly appropriated by the red particles to the exclusion of the degrading *fauve*. Another difference between these two principles is, that the yellow matter is more soluble in soaps and alkalies, and does not attach itself so permanently to the cotton as the red does, a circumstance which the dyers of the Turkey red avail themselves of, together with that already mentioned, to produce a red of great beauty; the Turkey reds are steeped, after dyeing, in a hot solution of soap in water, which removes the brownish yellow particles, but serves only to brighten the red;* but I shall treat more particularly of the Turkey red process a little farther on.

Most *plates*, (that is, cylinder work,) of medium sized figures, on a light ground, may be brought up to a boiling heat in from one to one and a half hour, for common block work two hours may be occupied; for still heavier work, that is, for heavy block work, and in other cases, where the surface of the cloth is mostly covered, as in those styles in which the cloth has been in the first instance altogether covered with the mordant, and small portions only discharged by printing an acid upon it, it is better to dye twice; at the first dyeing use about one-third the quantity of madder required for dyeing a full colour, bring up the heat in one hour to 180° Fahr., then draw off the liquor, replenish the cistern with water and the remainder of the madder, rinse, *edge up*, wash, and return the goods to the bath, which may be brought up to a boil in one and a half hour more; indeed, for such styles it is almost impossible in the usual mode of dyeing to obtain an even ground without twice dyeing; the cloth necessarily falls into folds, and the parts are unequally exposed to the action of the dye; if no more pieces were dyed at a time than what could be evenly spread upon the winch, the necessity of two operations would cease, but such an arrangement would involve a greater amount of labour than the one recommended.

Another reason for raising the temperature of the madder bath very slowly has already been anticipated, in part, in treating of the dunging process; the whole of the alum, and a part of the acetate of alumine of the red mordant, being in an unde-

* Berthollet very improperly recommends "adding a little potash the moment the madder is put into the copper, by which he observes the colouring matter is more easily extracted, and the colours more speedily raised," which is all true; but then the colours will be deteriorated in the same proportion.—Vide Ure's Translation, vol. ii. p. 117, of Elements, &c.

composed and soluble state, is liable to be removed from the cloth by a sudden rise of the temperature of the dying bath before the colouring matter has exerted its peculiar action in combining with and fixing it upon the cloth.

It is a rule with most madder dyers and calico printers to boil the calico fifteen minutes at the close of the dyeing; but the propriety of the practice is very questionable. Berthollet directs that the bath be brought to the point of ebullition; and expressly affirms that "the colouring matter is spoiled by ebullition." Dr. Bancroft is of a similar opinion, and doubts the expediency of using a higher temperature than can be borne by the hand; he suggests that, *if* there is any advantage in a higher temperature in rendering the colour more fast, the goods should be removed to a cistern of clean boiling water, and boiled there. There may be supposed a little economy in this practice of boiling, inasmuch as it is probable that more colouring matter is extracted from the madder by this means than could otherwise be done; but this colouring matter is of the grosser kind, a little of the red with a very large portion of the degrading brown and yellow, which it is a principal object with the dyer to avoid, combining with the cloth. Another great objection to the practice, is the dinginess it gives to the whites, which it is difficult wholly to remove without essentially impoverishing the colours we wish to preserve; in short, both theory and the observation of the best practical dyers are decidedly against it, and it is only remarkable that a practice so much at variance with all we know of the properties of madder should still be pursued by any.

The quantity of madder required in any given case must depend mainly on the depth of the shade intended, and the proportion of surface covered with the mordant, though something must be allowed for the colouring matter absorbed, for the time, by the unmordanted part of the cloth. The very lightest patterns may be dyed a full red, or black, with 8 lbs. to 10 pieces* of the best Dutch crop madder; the *average* quantity for cylinder patterns may be about double that amount; and for dyeing up a full colour on a padded piece, (that is, one which is wholly covered with the mordant,) 4 lbs. will be required. Great savings may be made in a large work by carefully ascertaining, where a new pattern is introduced, the exact quantity of madder, which may be necessary to dye it up; so, when a new lot, or even a new cask, of madder is opened, the utmost pains should be taken to compare it with previous lots of known

* Reference is here, and in all other cases in this article, where this term is used, had to pieces 26 inches wide in the *gray* (unbleached) state.

strength. These trials may be safely made, in the large way, without any essential interruption of the ordinary course of work, be sure to use little enough at first, and by the time the bath has acquired a temperature of 180° , or even before, an opinion may be formed whether more madder will be required to bring up the colour,* and, if more is wanted, it may either be added to the bath as it is, or the copper may be emptied, the goods washed, and the additional madder be added to a fresh bath; in the former case the temperature of the bath should be kept stationary from a half to three-quarters of an hour after putting in the additional madder.

The addition of about two ounces of ground Sicily sumach to each pound of madder has the effect to preserve the *whites* much clearer than they otherwise will be; the effect of sumach is to sadden the madder reds when used in a larger proportion; but so small a quantity is scarcely perceptible in this respect. Sumach is also said to render the madder colours more stable; but that is more questionable.

Dr. Bancroft recommends, or would seem to recommend, on the authority of Haussman, a celebrated French dyer, the addition of one-fifth or one-sixth of a pound of chalk or quicklime for every pound of madder. The results of my own experiments are directly at variance with this result; the addition of the chalk (I did not try the lime) greatly impoverished the dye. From this circumstance I am led to question the inference drawn from the fact as stated by Haussman, and I believe entertained by some others at this day, that natural waters, which hold the carbonate of lime in solution, are preferable for the madder dye.

A *rose* or pink hue is given to the colour of calico dyed in madder, on the aluminous mordant, by using along with the madder about double its weight of wheat bran; but the whites are much discoloured by this addition, and extremely difficult to *clear*. Nearly the same effect may be obtained by dyeing a little weaker mordant than that used for full reds.

The addition of the salts of tin, either to the mordant or the dyeing bath, is of no use whatever in madder colours, though still practised by some old dyers and colour mixers.

As soon as the dyeing operation is completed, the pieces are thrown into a cistern of cold water, where they are winched till most of the loose madder is removed; they are then *edged up*, and well washed in the dash wheel. The next operation is

* To ascertain the state of the goods, in this respect, the best way is to cut out a small slip from the end of a piece, wash it, and winch it for a moment in a weak solution of chloride of lime.

to boil them in a vessel of clean water, in which there has been infused a pound of wheat bran for every piece, for about twenty minutes; this is called by the workmen *branning*, after which the pieces are again rinsed, washed in the wheel, and *squeezed*, to prepare them for the last course of work in the wet way, which, in the technical language of the art, is called the *chemicking*, and which consists in winching the goods in a weak solution of chloride of lime. To prepare this liquor, make in the first instance a solution of bleaching powder of one pound to the gallon. If the bleaching powder be of a good quality the liquor will have a specific gravity of 5° T. Take one gallon of this solution, and add it to 200 gallons of water, and heat the bath to 100° Fahr.; this quantity of the solution is sufficient for ten pieces, which should be winched two at a time in the bath backwards and forwards the length of the piece about ten times. The moment the pieces are removed from this bath, they should be plunged into clean water, rinsed, and, immediately after, washed in the wheel again and squeezed; when they are prepared for drying, and finishing for the market, unless other colours are to be applied. When ten pieces are done, another gallon of the solution of bleaching powder may be added to the bath, ten pieces more entered, and so on, till fifty pieces have been done; when the liquor of the bath should be thrown away, and the cistern replenished as at the beginning.

It scarcely need be said that the object of the two last processes is to clear the whites from the colouring matters contracted in the dyeing bath, and the directions as to the quantities of bran and bleaching powder are to be considered merely as general rules for the workman, subject to great exceptions corresponding with the difficulties to be overcome; sometimes the whites are so little discoloured in the bath that a single branning is sufficient to *clear* them perfectly, and the solution of bleaching powder may be omitted altogether; at other times both operations require repeating; these differences are dependent on the bleaching, the qualities of madder, the temperature used in dyeing, the dunging, and other causes, some of which have already been noticed, and others remain to be pointed out. In general the colours dyed exclusively on the iron mordant, blacks and purples, come out of the madder bath with the clearest whites; reds have the whites more discoloured; and, what may appear singular, chocolates and other colours, dyed on a mixture of the iron and aluminous mordants, have the unprinted parts most discoloured, and most difficult to clear; this last circumstance is probably owing to the superior attraction of the aluminous base for the colouring particles, in consequence of which it appropriates the first that are dissolved

by the water, and partially suspends the operation of the iron mordant, which is in the mean time partly dissolved and fixed upon the whites.

It has long been the practice of many calico printers to use, instead of the solution of chloride of lime recommended above, a solution of a chlorate, (or *oxymuriate*, as it was formerly called,) of soda or potash. To prepare this liquor, add to a solution of chloride of lime in water, (one pound to the gallon,) at 5° T., ten ounces of the sal soda of the shops, or six ounces of commercial potash; stir the mixture for a few minutes; when the lime has subsided, decant the clear solution, which is called by the workmen *clearing liquor*;* this is the celebrated *lixivium of Javelle* of the French bleachers, which has long since given place to the chloride of lime in bleaching, but which is still retained by calico printers, under the idea that its operation is more mild, and that the lime in the latter has an injurious effect on madder *reds*. It certainly does not act so quickly as the solution of chloride of lime, but with suitable care the latter is equally manageable, and I have never been able to perceive any difference whatever in the effect produced on the madder colours by these two preparations. If my own observations are correct, therefore, the difference in the cost of these two solutions should determine a preference in favour of the simple chloride of lime. This operation of clearing the whites by the action of chlorine, whichever of the two preparations be used, is a very delicate one, and should be committed to a person of care and judgment. If the operation be too severe the colours may be essentially impaired. When the goods are ready for this process, if there be any material differences (as there frequently will be) in the amount of discoloration of the whites, the pieces should be carefully assorted into two or more classes, as the case may require, and the time of immersion proportioned to the obstructions to be removed. Where the whites are very dingy, I have found an advantage in adding to the solution of chloride of lime a small quantity of muriatic acid, (say in the proportion of 2 or 3 oz. to every 10 pieces,) this appears to answer better than to increase the strength of the clearing liquor by the use of more chloride of lime; and muriatic acid is better for this purpose than the sulphuric.

The *copper coloured spots*, which are frequently observed on the whites of goods that have been dyed in madder, and about which there have been such a variety of opinions among writers on this subject, as well as among practical printers, are clearly owing to the remains of oil contracted in the manufac-

* One gallon of this is used in the same way, and quantity, as a gallon of the solution of the bleaching powder without the lime.

ture, or at a subsequent time, and which has not been removed by the bleaching process. (Vide "Bleaching for Calico Printing" in this work.)

The pale cherry red stains, which sometimes involve the whole unmordanted surface of the piece, are also attributable to imperfect bleaching. In this case there seems to remain in the cloth some *natural* principle, which has the effect to fix to a certain extent the red colouring matter of the madder. We hear, however, much less complaint of these difficulties, and particularly of the former, since the general introduction of lime into the bleaching process.

It has often been asserted, that cloth which will receive water evenly, when the cloth passed through it, will dye well in madder, and afford good whites, and the same test of the fitness of cloth for madder colours has been proposed as for the reception of the indigo dye;* but nothing is more untrue. Fortunately we have a very easy test, and that is in madder itself; the process is this:—winch the bleached pieces a few minutes in a very weak and warm decoction of madder, (the liquor of a spent madder bath will answer every purpose,) and afterwards wash them well in the dash wheel; on pulling these pieces over a rail, between the eye and the light of a window, there will appear a slight discoloration of the whole surface; but, if no reddish, nor copper-coloured, or orange spots be observed, the dyer may rest assured that the bleaching has been effectual, and nothing is to be apprehended from that source in the madder bath: if, on the other hand, such stains are observed, in the slightest degree, he may be assured that they will become deeper in the usual process of madding, and rob him of the satisfaction of producing good work. Some printers are so particular in their work, as to test every piece in this way before printing; others content themselves with trying a few pieces from every bleached lot, and if no defect is observed in these, take the rest on trust.

In the foregoing remarks on madder dyeing, I have referred constantly to the Dutch crop madder as a standard of comparison, and purposely deferred to this stage of this treatise the few remarks I have to offer on the varieties of this article to be found in the American market. The principal sources, from which the supplies for calico printing are derived, are Holland and France; and from these countries it is, I believe, imported exclusively in the ground state. The Dutch or Zealand madder (the *Rubia Tinctorum* of Linn.) is imported under two denominations, the *Crop* and *Umbro*; the first is considered

* Vide the article "Blue Dipping" in this work.

the best, and bears a considerably higher price; both are manufactured from the same root; the difference is, or ought to be, that the *umbro* is made up mostly of the cortical part, which abounds most in the degrading or yellow colouring particles of this substance; and the crop chiefly from the interior of the root, which contains a larger proportion of the red matter, for which this drug is alone valuable. Formerly the Dutch made three varieties; the first was called *mor*, or *mull*, and was composed of the very outermost rind, the smallest roots, and earthy matter; the second, denominated *gort gemeen*, composed of about one-third the outermost part of the large root, and the third and last composed of the interior pure and bright part of the root; the separations were made by repeated poundings, siftings, and other mechanical means. Either these distinctions are not kept up by the cultivators, or the most inferior kinds are not invoiced to our merchants as such. The best Dutch madder is of a bright reddish yellow, and on nice inspection, even with the naked eye, will be found to abound in minute particles of a very bright red colour; it has an acrid sweetish taste, and is cemented together in casks in a very compact form, so much so that after the cask is destroyed the contents can only be severed by repeated blows of an axe; I have never met with a cask of madder, having all these properties, of an inferior quality; on the other hand, I have never known a cask of Dutch madder of a dark brown colour, and a soft consistence, that was worth using; between these two descriptions we meet with a great variety of qualities. The value of this article, of course, depends entirely upon the quantity of red colouring matter which it possesses. A very near approximation may be made to the comparative value of different samples, by the following experiment, founded on the solubility of the colouring particles in water;—place thirty or forty grains of each sample, in separate piles, upon a piece of board or other flat surface; flatten these piles a little at the top by any smooth surface, and expose them to the action of a damp atmosphere in a cellar, or elsewhere, for from 12 to 24 hours; when examined, at the expiration of that time, they will be found to have attracted sufficient moisture from the atmosphere to dissolve a portion of the colouring matter, and the depth of colour of the surfaces of the piles will indicate very nearly their comparative value.

The French madder, now much used by the calico printers, is a very different article in appearance, and, in some respects, in its habitudes; it comes in much larger casks than the Dutch, is much less compact, of a dark brown or snuff colour, and in a much finer powder than the latter. It is invoiced under six different marks indicating different qualities. The best quality

produces a finer red than the Dutch crop, and is now universally preferred by the dyers of the Turkey red in Great Britain; it is inferior, however, in strength to the best *crop*, and is more liable to discolour the whites in the dyeing bath. The two or three first qualities are, alone, well suited to the purposes of the calico printer, and these, at the prices they have borne in the market for the last two or three years, I have found to be a little cheaper in use than the Dutch crop. The lower qualities are used, I believe, to better advantage by the woollen dyers. The comparative strength (in colouring matter) of different samples may be tested in the manner already described above. The French madders are the product of the genus *Rubia Peregrina* of Linn., formerly imported into England exclusively from the Levant, in the roots, in which form it is occasionally met with in this country.

Turkey Red.

I shall conclude this article by a description of the modern French method of dyeing the Turkey or Adrianople red, which is now universally practised in England and Scotland. For the more complicated and tedious method of the old dyers, I must refer the reader to the elaborate works of Bancroft and Berthollet.

Take 20 lbs. of olive oil;*
20 ounces of potash;
16 gallons of water.

Dissolve the potash in half a gallon of the water; then warm the oil, and add it by degrees to the remaining water, which should also be warm, and beat them together with a bundle of twigs; lastly, add the solution of potash, and renew the agitation until the whole assumes the appearance of a milk-like fluid. In this liquor the cloth, previously half bleached, is padded twice, and dried four consecutive times, (that is, it is padded eight times and dried four,) at a temperature not exceeding 170° or 180° Fahr. It will require about six quarts of liquor for the eight paddings, *per* piece. It is then boiled half an hour in a solution of pearl-ash of one and a half ounce to the gallon, then winched a few minutes in hot water, and washed in the dash wheel. The cloth is now prepared for the mordant, which is prepared from three pounds of alum, and two and a quarter pounds of sugar of lead, to one gallon of water; if printed with the cylinder, the mordant is used of the full strength for a full red, and thickened with starch; *if padded*, for a full red, two parts

* The most inferior kind of olive oil, called in commerce the Gallipoli Oil, is always used for this purpose.

of the liquor are diluted with one water; for a rose pink, use one mordant and five waters. After the mordant is applied, the pieces are boiled in bran and water (one pound to the piece) twenty minutes, rinsed, and washed in the wheel. The pieces are then dyed, first in three pounds of French madder, and twelve ounces of bullocks' blood to the piece; the temperature is brought up to 150° or 160° Fahr. The pieces are then taken out of the bath, rinsed, edged, washed, and dyed a second time in four pounds of madder, and twelve ounces of blood to the piece. The temperature is brought up to a boil in the second dying in one and a half hour. The goods are then boiled three hours in the bran copper, rinsed, and washed,—exposed two days upon the grass,—boiled again in white soap, three ounces to the piece,—bleached again on the grass three or four days,—cleared in the oxymuriate of lime, or potash, in the usual way,—washed,—boiled again in soap, and, lastly, cleared again in the oxymuriate of potash or lime. These directions apply in their full extent to goods that are *printed*, and have whites to clear. On the *padded* pieces the use of the oxymuriate of lime, or potash, the *crofting*, or bleaching on the grass, and, perhaps, one branning may be omitted altogether. This is substantially the Turkey red process, as now practised by the best dyers in England; yet, perhaps, no two pursue precisely the same course of work, nor use exactly the same proportions of the materials prescribed, and as usual an undue importance is attached by the workmen to slight variations, which do not effect the principles of the process. The most material point in which this differs from the common operation of madder dyeing, is in the preparation of the cloth with the alkali and oil, and the oftener this process is repeated the brighter will be the colour. Some printers produce pretty good reds with only four times padding; others, who aim at great excellence in the art, pad as many as ten times. The use of the oil supersedes the necessity of dunging in this process; indeed, although cow dung actually improves the depth and beauty of common reds, yet it is incompatible with the highest degree of lustre, of which the madder colour is susceptible in the Turkey red process.

Alkaline Solution of Alumine.

Another mordant for reds is a solution of alumine in caustic potash. It is prepared as follows:—Dissolve three pounds of alum in one quart of water, at a boiling heat; then pour into this solution two quarts of caustic potash ley at 40° T.; a dense white precipitate of alumine is instantly produced, which must be added together with the other matters of the mixture, (the water and the sulphate, or the super-sulphate of potash,) to three

quarts more of a caustic ley of the same specific gravity as the first, and at a boiling temperature (of water.) Boil the whole till reduced to one gallon, and when cold pour off the clear liquor, and wash the sediment, which is a crystallized sulphate and super-sulphate of potash, with as much water as will make one gallon of clear liquor. This is the alkaline solution of alumine. It is thickened with British gum. After printing, the goods are hanged for 12 or 24 hours in a damp atmosphere, and then winched in a solution of muriate of ammonia, sulphate of zinc, or sulphate of magnesia. Dye in madder without dunging.

In the first step in the foregoing process the alkali combines with the sulphuric acid of the alum, forming a super-sulphate of potash, and remains in solution; and the alumine is precipitated, (in the chemical sense of the term,) but, being very light, does not readily subside. In the second step of the operation, the addition of the precipitated alumine to a fresh portion of alkaline ley, the alumine is redissolved, not in acid, but in the potash; the reason why the whole amount of potash required for the precipitation and solution of the alumine is not added at once is, that in that case a neutral sulphate must be formed, which must necessarily require more potash; and the same reason obtains for the direction to add in the second step the precipitated alumine to the potash, and not the potash to the alumine.

This solution of alumine is so extremely soluble in water that it cannot be fixed in the usual way that the acetate of alumine is done; the moment the cloth should enter the dung liquor a portion of the mordant would spread and fix upon the ground, but a larger part would be dissolved and removed from the cloth entirely; in the *fixing* process directed, the acid of the salt combines with and neutralizes, and precipitates the alumine upon the fabric and the alkali, metal or earth not acting as a mordant, and being incapable of dissolving the alumine, will leave it in undisturbed possession of the cloth. This solution will bear some dilution, even for the deepest reds. The alkaline solution of alumine is a cheaper mordant than the common aceto-sulphate of the same earth, and I think its use should be more general than it is. An opinion prevails among calico printers that it requires more madder to produce a given effect than the common red mordant; my experience does not enable me to say whether or not this opinion is well founded.

Padded Alkaline Pink.

Take one gallon of the alkaline solution of alumine, as prepared above, and dilute with four or more gallons of water, ac-

cording to the shade intended, and, to every twenty-four measures of the solution, add one of olive oil, and mix well. Pad the pieces, and fix, as above directed, in sal ammoniac, sulphate of zinc, or sulphate of magnesia; I prefer the first for pinks. Dye in madder, (French,) and brighten with soap. This will give the Turkey red hue to the colour. For common pinks the oil may be omitted, and the colour will then be brighter and more even than when the aceto-sulphate of alumine has been used.

If a chrome yellow is to be printed as a discharge on this ground, the goods, after fixing, and before dyeing, should be scoured in a weak solution of pearl-ash (half an ounce to the gallon) to remove any superfluous oil. (For a farther application of the alkaline solution of alumine, vide *Warwick's Green*.)

Of Colours Dyed with Quercitron Bark.

The mordants for the quercitron bark (*quercus nigra*, or black oak,) are the same as for madder colours. It is usual, however, to sighten the aluminous mordant with the quercitron bark itself, to enable the dyer to select pieces intended for this colour from those designed for the madder reds; the dyeing can also be completed in a shorter time, for, if Brazil, or peachwood be used for sightening, it combines with the aluminous base, and some time is required to displace it, by the superior attraction of the bark.

The treatment of goods designed for dyeing in the quercitron bark, the thickening of the colour, the printing, the ageing, dunging, &c., whether printed with the aluminous or the iron mordant, is the same as for the madder dye, with the exception that it is not often necessary to dung the pieces but once for those colours, of which the iron mordant is the base.

With the aceto-sulphate of alumine at 18° T., prepared from sugar of lead and alum, the bark affords a full bright yellow when printed with the block, and for lighter shades will bear a dilution with from two to three waters. This liquor is always to be preferred to the same mordant prepared from the pyrolignite of lime and alum, which never affords so bright a colour. The aluminous mordant is seldom printed by the cylinder for yellows.

Iron liquor at 18° T., printed with the cylinder, affords with quercitron bark a dark greenish brown, or bottle green; at 12° T., a light drab. The same mordant, at 18° T., produces with the block almost a black; and, with one to four, or five waters, various shades of drab. Mixtures of the iron and aluminous mordant, in different proportions, produce various shades of

olive, from a yellowish green to a greenish yellow, according as the iron or aluminous base predominates, and the amount of dilution of one or both.

The dyeing of yellow with quercitron bark is a very simple and expeditious process. Three pounds of the ground bark is sufficient to dye a padded piece of a full yellow; but as this is a cheap drug, and an excess will enable the dyer to operate at a lower temperature, and, to expedite the process, it is usual to use in all cases, at least, from one and a-half to two pounds to the piece. The goods are entered cold, and the bath is gradually brought up to the temperature of 100° or 120° Fahr. at the most. From a half to three-quarters of an hour is required to complete the dyeing. The lower the temperature used, the brighter, and, according to Dr. Bancroft, (to whom is due the merit of introducing this valuable drug to the attention of European dyers,) the more permanent will be the colour. If a temperature approaching a scalding heat be employed, the yellow will not be so bright, and the grounds, or whites, will be more discoloured. To improve the beauty of this dye, or to preserve the grounds from discoloration, the use of glue, cream of tartar, sumach, potash, and other substances, have been from time to time proposed and used; but I purposely omit a more particular notice of them, because I have ascertained that equally good effects can be produced without them by following the above simple directions; when a slight branning, and sometimes a washing, alone will suffice to produce the clearest grounds.

A peculiarly rich orange tint is given to the quercitron bark yellow, by adding to the dyeing bath a small quantity of lime, or, what is preferable, lime water, which in some styles of work is much admired.

In those styles of work having a yellow ground, a most brilliant and beautiful yellow is produced by the addition of eight or ten ounces of the liquid proto-muriate of tin of a specific gravity of 114° T. to the dyeing bath for every ten pieces. This colour is not so fast as that dyed wholly on the aluminous basis, but it is more permanent than that dyed on the tin mordant alone. The fashionable prints of purple figures on a Canary ground, so much worn the last two or three years, owe their chief excellence to the uncommon delicacy of this colour. The goods are first printed and dyed in the usual way, in madder purple figures, then padded in the aluminous mordant from sugar of lead and alum of a specific gravity of 12° T., hot watered (not dunged) at 140° Fahr., and dyed as above described. The padding liquor is thickened with one-thirtieth part by measure of gum water at 35° T. It will be obvious that the tin mordant cannot be used for dyeing printed yellows where

there is a white ground to protect, as the tin will fix a portion of the colouring matter on the grounds, and render it impossible to clear them without destroying also the beauty of the topical yellow: neither can it be used with those colours upon which the acid of this salt would operate as a *discharge*.

The directions given above for dyeing with bark on the aceto-sulphate of alumine are equally applicable to dyeing on the iron mordant, and on mixtures of the two mordants.

Mixtures of madder and quercitron bark, dyed on the aluminous mordant, produce various shades of orange, according to the proportions of each and the strength of the mordant; but, owing to the superior depth of colour and attraction of the madder for the mordant, the bark must, in every case to produce much effect, be in considerable excess.

Buff Colour.

This very simple, but fast colour, is produced by printing on the calico an acetate or sulphate of iron, and precipitating the oxide upon it by passing the cloth through a solution of potash, or milk of lime. For the roller we use the green acetate, or rather the aceto-sulphate, prepared as follows:—

Take 4 lbs. of proto-sulphate of iron;
2 lbs. of acetate of lead;
1 gallon of water.

Dissolve the copperas in the water by heat, and when the solution is completed, add to it the sugar of lead, and stir the mixture two or three minutes; then let it stand, and when the sulphate of lead has subsided, decant the clear liquor, which will have a specific gravity of 29° T.; and thicken with flour, gum Senegal, or British gum. The first is most commonly used on account of its cheapness; the two last are preferable for some patterns. I have not been able to find a good material for *sightening* for this colour; none of the usual vegetable colouring matters will answer, for an obvious reason. It has been the practice of many colour mixers to employ the Venetian red for this purpose; but it is difficult to remove it from the cloth afterwards. The *high dried* British gum answers in most cases both for thickening and sightening; and where this cannot be used, it is, perhaps, better to do without any. This liquor, when used without dilution, affords what is called by the printers a *gold* colour; diluted with one, two, or more colours, different shades of buff.

For padding light grounds, dilute the liquor with 10 to 15 waters, and thicken with about twelve ounces of gum Senegal to the gallon.

Buff Liquor for the Block.

Take 1 gallon of water;
4 lbs. of proto-sulphate of iron;
2 oz. of concentrated sulphuric acid.

Thicken with gum Senegal. This liquor will produce a strong buff, or gold colour, and for lighter shades may be diluted to any amount desired. The sulphuric acid serves to keep that part of the iron, which becomes converted into a peroxide, from precipitating; the temperature at which the cloth is necessarily exposed, and the action of the acid on the *doctor*, forbid its use in machine printing.

Printed and padded buffs require ageing three or four days, and should be hanged in a cool room, otherwise the thickening becomes so hard as to resist the penetration of the liquor in the process of *raising*. There is no serious objection, however, to raising the buffs the day after printing; but the longer they hang exposed to the air, the darker will be the shade; at least they will continue to grow darker for eight or ten days.

Raising Buffs.

To do this in the best manner, provide a cistern with rollers, precisely like that used for fly dunging, having a frame with about four pairs of rollers, over and under which the cloth is conducted so as to expose the surface evenly and extensively to the action of the raising liquor; from this cistern the cloth should pass directly into another cistern filled with clean water, and provided also with one or two pairs of rollers. For the raising liquor, take 8 lbs. of pearl-ash and 40 lbs. of lime; fill the cistern so as to cover the top row of rollers, and then add the pearl-ash and lime, and keep the lime suspended in the water, by stirring, while the cloth is passing through the liquor: the speed should be such as to expose the cloth about one minute to the action of the lime liquor. From the rinsing cistern the cloth is removed instantly to the dash wheel, well washed, and *edged up*; it is then winched in a cistern of water at a temperature of 140° to 160° Fahr., washed again, squeezed, and dried *in the air*. Nothing is more simple than this operation, and yet, unless great caution be used, scarcely any one in the art is more liable to miscarriage. Whether the goods be exposed to the action of the liquor by the hand, or over rollers in the manner described, the utmost care should be used, on entering them, not to allow any part of the cloth to touch the liquor till it is fairly immersed in it: if it be wetted by the liquor; and then suddenly withdrawn, for the shortest space of time only,

the colour will come out of the cistern uneven; or, if the *face* side of the cloth be allowed, on entering the liquor, to touch itself in any part, the colour is sure to be uneven; on this account, when the goods are entered by hand, the stick, which is commonly used, should be thrust upon the *back* instead of the *face* side of the cloth, otherwise this accident will frequently occur. The sooner the cloth is rinsed, and washed, after the operation, the better it will be; for this purpose *straining** is best where it can conveniently be resorted to.

Bronze Colour.

Take 4 lbs. of the sulphate, muriate, or acetate of manganese;
1 gallon of water.

Dissolve the salt in the water, and thicken with gum Senegal. Pad the cloth the same day (if convenient, but no injury will accrue from laying a day or two) in a solution of caustic alkali at 10° T.; and, without drying, washing, or rinsing, winch the pieces through a solution of the chloride of lime of a specific gravity of 1½° T., or, of about 4 oz. to the gallon;—25 lbs. of the bleaching powder to 100 gallons of water will answer for 50 pieces printed in the heaviest figures; after winching that number, the liquor should be drawn off, and a fresh solution made, otherwise the whites will be injured.

The theory of this operation is very similar to that of producing the buff from the salts of iron. All the salts of manganese have a protoxide for their base; the alkali precipitates the oxide from its base, and, in the second operation, the chlorine and the oxide decomposing a portion of the water, by what chemists have denominated a *predisposing affinity*, the hydrogen unites with the chlorine, forming muriatic acid, and the oxygen with the protoxide of the manganese, converting it into, perhaps, a peroxide.

Where a very dark *ground* is wanted for discharging afterwards, the alkaline solution should have a specific gravity of 18° T. at 60° Fahr., and when the pieces are padded should be kept at a temperature as near a boiling heat (212°) as possible. Particular care should be used to keep the temperature as equal as possible, to ensure an even ground.

When it is practicable to get a sufficiently dark shade without the use of the chloride of lime, it is better to omit it; for, although it deepens the colour, it also saddens it. Instead of winching in the chloride of lime, some printers hang the goods

* This operation consists in holding the piece by one end in a rapid current of water.

with the potash liquor in them two or three hours; then wash in hot water, and put through soft soap and boiling water;—wash again, and dry for printing.

A Dark Brown,

Somewhat similar in appearance to the bronze above described, is produced in the following manner:—

Take half a gallon of caustic potash ley at 36° T.;
1 lb. of orange orpiment.

Dissolve by heat, and then dilute the solution with half a gallon more water, when the solution will mark 18° T. Print by the roller, and hang a few hours. Give the pieces eight or ten ends* in a solution of sulphuric acid in water at 2° Fahr's. Hyd.;—rinse and wash in the wheel. Lastly, winch the pieces in a solution of acetate of lead, allowing 4 oz. to the piece;—winch in water at 180° Fahr. eight or ten minutes; wash well, and squeeze.

The object of these processes is to fix upon the cloth a sulphuret of lead. The orpiment is a sulphuret of arsenic;—the effect of the sulphuric acid is to precipitate, by combining with the potash, which holds it in solution, the sulphuret upon the cloth in the same state as it was previous to its solution; in this stage of the process we have a beautiful yellow, but it will not bear the action of a solution of soap; the effect of the acetate of lead is to produce a double decomposition,—the acetic acid of the lead seizes the arsenic of the orpiment, and the sulphur of this orpiment forms an insoluble sulphuret of lead. This colour is very fast, and is not affected by the madder dye.

Chrome Yellow.

Take 2½ lbs. of nitrate, or acetate of lead;
1 gallon of water.

Thicken, cold, with British gum. Print, and after hanging 12 hours, wet the pieces, and then winch in a solution of bichromate of potash, of 1 oz. to the gallon, for fifteen minutes;—for medium sized figures, use 2 oz. of the bichromate to each piece. The colour will be a little deeper by wetting the pieces, previous to chroming, in a solution of potash in water, of 2 oz. to the gallon, and washing; but it is cheaper to use a little stronger solution of lead, if a deeper shade be wanted.

In this process there is a double decomposition of the salt of

* The workmen's phrase, implying passing the pieces so many times from end to end through a liquor by means of a winch.

lead and the bichromate of potash, and the result is a nitrate or acetate of potash, which remains in solution, and an insoluble chromate of lead, which is fixed upon the cloth. This colour may be printed with either the black or cylinder, but is not much practised except in connexion with certain *discharge* styles, which will be treated of by and by.

Chrome Orange.

Dissolve 2 lbs. of nitrate of lead in 1 gallon of water, and thicken with gum Senegal. Winch the cloth after printing in a solution of sulphate of magnesia, of 1 lb. to the gallon. Raise in the chromate of potash (yellow chromate) 2 oz. to the piece, and then winch the goods in boiling lime water; do not enter the pieces till the lime water boils. Perhaps alum might be advantageously substituted for the Epsom salts.

Prussian Blue.

Print the cloth in the mordant for a black; age one week, and dung the pieces as for madder colours; then winch them in a solution of prussiate of potash slightly acidulated with sulphuric acid. Medium figures will require about 2 oz. of prussiate of potash to the piece. Some printers direct that the pieces be winched in lime water, previous to dunging, but the practice is unnecessary.

The theory of the formation of this colour is very simple; the prussiate (or more properly the *ferrocyanate of potash*) is decomposed by the sulphuric acid, which unites with the potash, forming sulphate of potash, and the disengaged ferrocyanic acid combines directly with the peroxide of iron, forming the beautiful compound, so well known as a pigment, prussian blue, or the ferrocyanate of iron. This colour is unaffected by air, water, or weak acids, but wants the most essential requisite of a fast colour, that of resisting the action of alkalies and soaps.

A solution of ammoniuret of copper was for some years manufactured and sold to the calico printers in Lancashire, England, by the name of the *prussian blue fixer*, but I believe its claims to that title are now questioned by the most intelligent of the trade.

Chemical, or Spirit Colours.

These terms, absurd as distinctive appellations, are applied to those colours in which the mordant and colouring matter are mixed previously to their application to the cloth, and in general require no farther operation to fix them after printing. They are not so fast as those colours in which the cloth is first impressed with the mordant, and afterwards dyed, even where the

same mordants and colouring matters* are used. This difference is owing to two causes, one or both of which apply in every case;—1st, The cotton does not possess so strong an attraction for the mordant and colouring matter respectively as they do for each other; and, therefore, where the mordant and colouring particles are previously united, as they must be to a considerable extent before their application to the cloth, their strength of attraction is such as to exclude the effective attraction of the cloth for them, and instead of a ternary compound of the mordant, colouring matter, and the cloth, there is a compound of the two former merely, mechanically precipitated upon the latter; 2dly, In those cases where the cloth may be supposed to possess naturally as strong an attraction for the mordant and colouring matter as the latter have for each other; this attraction is rendered in a great measure ineffectual by the insolubility of the compound previously formed by the latter. This difficulty is, in some degree, obviated by preventing, as far as possible, the union of the mordant with the vegetable colouring matter by the mechanical properties of the thickening, and the manner of mixing them. In general a watery decoction of the dye stuff is first made, and thickened with flour, starch, or gum, and the mordant is added afterwards, by which means the vegetable matter is in a degree enveloped and shielded from the action of the mordant till both are united with the cloth.

Chemical Black.

Take 12 measures of a decoction of galls at 14° T., thicken with flour; when cold, and about to be used, add one measure of liquid nitrate of iron at 84° T. The decoction of galls will require about 3 lbs. of nut galls to one gallon of water. Some printers use, in conjunction with the decoction of galls, a decoction of logwood; but it is unnecessary. Age one week after printing, then wash, &c.

Chemical Black (from Logwood.)

Boil 4 lbs. of logwood chips in two gallons of water, to one gallon; filter, and add to the clear decoction 12 oz. of sulphate of copper; thicken with flour, and when cold, and about to be used, add one pint of liquid nitrate of iron, at 84° T. This is a cheaper colour, but not so fast as the preceding. Some co-

* By *colouring matter*, in this connexion, and in most other cases where it is contrasted with the term *mordant* in this treatise, is meant merely the vegetable principle, which, although it may not even possess any colour of itself, when united with an earthy or metallic matter, produces colour.

lour mixers substitute the sulphate for the nitrate of iron in their chemical black; but it does not thicken nor work as well.

Chemical, or Berry Yellow.

Take one gallon of a decoction of Persian berries of a specific gravity of 4° T., and dissolve in it 8 oz. of alum; thicken with flour. After printing, the cloth is winched in lime water, or what is called milk of lime, (that is, water made milky by quicklime,) by this means the colour is rendered much brighter than it otherwise would be by precipitating and combining a larger portion of the aluminous base upon the cloth. Where this exposure to the action of the lime would injure other colours, previously applied, it may be dispensed with by substituting the aceto-sulphate of alumine for the alum. To prepare the decoction of Persian berries for the foregoing colour, take 25 lbs. of Persian berries, and boil them in 20 gallons of water for 16 hours; then strain off 13 gallons of the liquor; add to the berries 20 gallons more water, and boil 16 hours more, when the berries will have become soft and deprived of all their colouring matter; strain off the remaining clear liquor (about 12 gallons) and add it to the first.

Spirit Red, or Peachwood Wash-off Pink.

Prepare a strong decoction of peachwood, in which the colouring matter of 100 lbs. is contained in 12 gallons of water; take one gallon of this decoction, thickened with starch or flour, one gallon of the liquid nitro-muriate of tin at 80° T., and two gallons of gum water: 4 oz. of blue vitriol is an improvement. Age 24 hours after printing, and then simply wash the goods. Brazil-wood abounds more in colouring matter, but is thought by most printers not to yield so fine a colour. The decoctions of both peachwood and Brazil-wood improve by age, according to Dr. Bancroft. The nitro-muriate of tin should be added to the thickened decoction when cold, and only when wanted for use. This colour is very beautiful, but not fast.

Spirit, or Wash-off Purple.

Take four measures of a decoction of logwood at 8° T.; thicken with starch, and when cold, and wanted for use, add one measure of liquid nitro-muriate of tin at 80° T. Print, and hang at least 24 hours before washing off. This colour, like the last, is extremely beautiful, but very fugitive.

Cochineal Pink.

To one gallon of water add one pound of cochineal as fine as flour; boil half an hour, and then add 2 oz. of finely pulverized

gum dragon, and 2 oz. of cream of tartar, and stir till the whole is dissolved; when the liquor is cool, add one measure of solution of nitre-muriate of tin at 80° T., to two of the cochineal liquor, and incorporate well by stirring. Print, and hang 12 hours before washing off. This formula is taken, substantially, from the article "Colour Mixing" in Rees' Cyclopædia. It ought rather to be called a scarlet. It is very fugitive.

By mixing the decoctions of peachwood and Persian berries, or of peachwood and quercitron bark, and of peachwood and logwood in different proportions, and proceeding in other respects as in the three foregoing formulæ, a great variety of orange, brown, purple, lilac, cinnamon, and other colours may be produced of great beauty; but their want of fastness precludes, or ought to preclude, their use in the art. A colour dependent solely on the tin basis cannot be said to be fast, in the acceptance of the term, as used by calico printers; it may, indeed, bear the action of acids, and repeated washings in soap and water, without much change, but it will not endure the action of light.

Steam Colours

Are those in which the mordant and colouring matter are mixed, as in *chemical* colours, previous to their application to the calico, but which are afterwards fixed more permanently upon the cloth by the application of steam. For this purpose, a hollow cylinder of tin or copper, six or eight inches in diameter, pierced with holes like a colander, closed at one end, and connected by a pipe at the other, with a steam boiler, is first wrapped round with several thicknesses of flannel, next with a piece of unbleached calico, and then with the printed goods, (say eight or ten pieces,) afterwards with a piece of gray calico again, and, lastly, with several folds more of flannel. The steam from the boiler, at a temperature somewhat above that of boiling water, on turning a cock, is forcibly driven through the pipe into the cylinder, and having no other means of escape, gradually penetrates the substance of and escapes in volumes from its surface. Great care is required that no water rushes in with the steam, as that would soften the thickening and make the colour spread: the object of the first folds of calico and flannel is to absorb any water that may be violently projected from the steam pipe, and of the outermost folds to prevent such a loss of heat as would cause the steam to be condensed on the printed calico. In this process the steam seems to produce such a partial softening of the paste as enables the chemical action to take place without spreading beyond the limits of the figure;—the temperature is doubtless highly favourable to the exertion

of chemical attraction. It is, in fact, a topical dyeing. At the expiration of twenty or thirty minutes the steam is stopped, the goods are unrolled, and, though reeking with steam, are perfectly dry to the touch, the sensible heat being sufficient to carry off the whole without leaving any moisture upon the calico.

The high temperature employed in this operation precludes the use of the nitro-muriate, or, more properly, permuriate of tin, which would prove ruinous to the texture of the goods, if employed in the manner in which it is done in the preparation of *chemical* colours. The mordant employed in its stead is what the printers call a *double acetate of alumine*, prepared from four pounds of alum and four pounds of sugar of lead per gallon of water, which is a solution of the acetate of alumine with a small excess of the sulphate. The Lancashire calico printers have, however, within a few years devised means by which they have been enabled to combine in this style of printing the peculiar action of both mordants, and to secure, in a considerable degree, the brilliancy of colouring produced by the one, and the permanency of the other; this important object is effected by impregnating the whole body of the cloth, previous to printing, with an alkaline solution of the oxide of tin, and precipitating it upon it; the operation is known to printers by the term *preparing* cloth, and the calico thus treated is called *prepared* cloth;—for this purpose take 16 measures of a solution of caustic potash at 20° T., and add to it one measure of the oxymuriate of tin at 120° T.; pad the cloth with this solution, without heat, and dry it the same day;—fix (precipitate) the oxide of tin by winching the cloth through a solution of sal ammoniac of 6 oz. to the gallon; then wash well, and dry for printing.

Steam Cochineal Pink.

Take seven pints of a decoction of cochineal of 2 lbs. to the gallon, one pint of double acetate of alumine; thicken with starch; when boiled, and while yet hot, add 4 oz. of oxalic acid, and cool as fast as possible;—steam twenty minutes;—print, of course, on prepared cloth. Oxalic acid is added to all steam colours, containing cochineal, to counteract the effect which the salts of alumine have upon that colour, that of giving the pink a purple hue.

Steam Yellow.

Take one gallon of a decoction of Persian berries at 8° T., when nearly cold, add 12 oz. of alum and one gum water, mixed well together, and dissolve in it two ounces of nitre;—print on prepared cloth, and steam 25 minutes.

Steam Black.

Take 2 lbs. of galls (nut galls) and 1 lb. of logwood chips;—boil the chips well, and then add the galls, and boil two or three hours, so as to extract all the colouring matter, and then evaporate, or add, as the case may require, to make one gallon.—Thicken with equal parts of starch and flour; while thickening, add 4 oz. of the sulphate of iron; when cold, add half an ounce of nitrate of iron, including one-eighth of an ounce of nitrate of copper. Steam 20 minutes, after ageing one week.

Steam Lilac.

Take one part of a decoction of logwood at 6° T., one part of a decoction of peachwood at 8° T., one and a half part of double acetate of alumine, and four gum waters.

Park Olive.

Take three parts of a decoction of nut galls, of 2 lbs. to the gallon, one part of a solution of nitrate of copper, of 1 lb. to the gallon, ten parts of a decoction of Persian berries at 4° T., containing three-quarters of a pound of alum *per* gallon, and twenty gum waters at 34° T.; print, and steam 20 minutes.

Pale Drab, or Olive,

Is prepared from one of the above, and ten more gum waters.

Steam Orange.

Take one measure of a decoction of cochineal, of 2 lbs. to the gallon, and ten measures of a decoction of cochineal at 4° T.

Another Steam Orange.

Take four parts of Persian berry liquor at 10° T., three parts of a decoction of cochineal, one part of double acetate of alumine; thicken with starch, and, when nearly cold, add 4 oz. of oxalic acid to the gallon. Print, and steam 20 minutes.

Steam Cinnamon.

Take a quarter of a gill of double acetate of alumine, one and three-quarters of a gill of a decoction of logwood, at 6° T., and two ounces of starch; boil, and, when nearly cold, add one and a quarter ounce of oxalic acid, and mix the whole with seven quarts of the above orange. Steam 20 minutes, and then pass the goods through caustic potash ley, at 20° T., with eight ounces of alum *per* gallon.

Another Cinnamon.

Take one and a half gill of a decoction of Persian berries at 10° T., one and a half gill of a decoction of cochineal, 2 lbs. to the gallon, four and a half gills of a decoction of logwood at 6° T., four and a half gills of double acetate of alumine; thicken with starch, and, when cold, add two and a half ounces of oxalic acid. Steam 25 minutes.

Park Cinnamon.

Take one pint of a decoction of Persian berries at 12° T., three gills of a decoction of cochineal of 2 lbs. per gallon, three gills of double acetate of alumine, eight ounces of flour; thicken, and, when cold, add three ounces of oxalic acid.

Steam Bronse.

Take one and a quarter pint of a decoction of Persian berries at 10° T., one and a half pint of a decoction of cochineal, of 2 lbs. to the gallon, half a gill of double acetate of alumine; thicken with starch, and, when cold, add one ounce of oxalic acid. Steam 25 minutes.

Another Steam Cinnamon.

Take one gill of a decoction of Persian berries at 10° T., one gill of acetate of alumine; thicken with starch, and add, when cold, two ounces of oxalic acid.

Steam Chocolate.

Take twelve gills of cochineal decoction of 2½ lbs. per gallon, four gills of a decoction of Persian berries at 10° T., four gills of a decoction of logwood, of 8 lbs. per gallon, two and a half ounces of muriate of ammonia, and nine ounces of alum;—thicken with starch, and steam 25 minutes.

Steam Deep Brown.

To the foregoing steam chocolate, add one ounce of the sulphate of iron, and steam, after ageing a day or two.

Steam Brown, (another.)

Take two quarts of a decoction of Persian berries at 10° T., two quarts of a decoction of peachwood at 10° T., one pint of a decoction of logwood at 6° T., six ounces of sulphate of iron, and six ounces of cream of tartar.

Prussian Steam Blue.

Take one gallon of water, one and a quarter pound of prussiate of potash, one and a quarter pound of tartaric acid. Dis-

solve the prussiate of potash first, and then the acid. Thicken the clear liquor with starch. Print and steam, and then winch the cloth in a solution of chloride of lime, of one ounce to the gallon.

Five ounces of sulphuric acid, and one and a quarter pound of tartaric acid, or, what is cheaper still, one and a quarter pound of bi-sulphate of potash, may be substituted for the one and a quarter pound of tartaric acid directed.

When this colour (or rather mordant) is printed on *unprepared* cloth, and dyed in madder, it becomes a bright purple, called by the English printers *French purple*.

Steam Green.

Take one measure of a decoction of Persian berries at 4° T., and one measure of the Prussian Steam Blue above; mix, and thicken with starch. This and the preceding colour are both easily discharged by caustic potash, or even by a solution of common soap.

DISCHARGES PRINTED ON PADDED GROUNDS.

Black and Whites.

Take one gallon of aceto sulphate of alumine, prepared from pyrolignite of lime and alum, at 22° T., three gallons of iron liquor at 12° T., and one gallon of water; mix.—Pad the cloth in this liquor at a temperature not exceeding 220° Fahr., and immediately afterwards print it with the following *acid paste*:—

Take lime, or lemon juice, boiled till it have a specific gravity of 30° T. Thicken with 5 lbs. of British gum to the gallon. If the paste be too thick, the printer may be furnished with unthickened acid at 30° T., and be allowed to reduce its consistence to suit the engraved pattern. Some printers use the acid at 20° T., or 25° T. Something depends upon the nature of the pattern: a more concentrated acid is required for a fine engraving than for a coarse one. The super-sulphate of potash has long been employed in the discharge pastes, for this style of printing, as a substitute, in part, for the citric acid, which is more expensive: the following formula is recommended by a skilful calico printer, recently from England.

Take 1½ of a gallon of citric acid (crude as above) at 20° T., 26 oz. of super-sulphate of potash in crystals; thicken the citric

acid with starch, (for medium, or average figures, 4 lbs. to the gallon,) and when well boiled, and while yet hot, add the sulphate of potash. After printing, age the pieces seven days;—fly dung them at 200° Fahr.; rinse, edge up, wash, and dung them a second time at 180° Fahr.; after which they are rinsed, edged, and washed again, and then dyed in a bath of ground logwood, 3 lbs. to the piece;—bring up to a boiling heat in one hour, and boil fifteen minutes. The subsequent processes are the same as after madder dyeing, with the exception of the clearing in the solution of chloride of lime, which is omitted in this style of work.

If madder be substituted for the logwood in this style, we obtain the same effect, and a much *faster* colour, but rather inferior in point of depth and beauty; the difference is not so great, however, especially if a little logwood be used in conjunction with the madder, that this consideration alone should determine the printer in the use of the latter; the logwood dye is alone employed by the English calico printers, and it would be impossible for our printers to compete with them in our own market, and use so expensive a drug as madder, for it is difficult for buyers to distinguish clearly the one from the other, and even if they could do so, the lower price at which the logwood blacks can be afforded would determine the choice in their favour.

The theory of this style of printing is extremely simple; the mordant padded upon the cloth is the pro-acetate of iron; the acid of the paste decomposes this salt on the parts on which it is applied, combines with the oxide forming a soluble salt, which is dissolved out in the processes of dunging and washing previous to dyeing; the acetic acid is expelled for the most part, in vapour by the heat used in printing, and by the subsequent exposure to the air. The sooner the pieces are printed after padding the better will be the discharge; if the printing be delayed, the acetate of iron becomes decomposed, and the protoxide attracting oxygen from the air passes into the peroxidized state, in which, when combined with the cloth, it is insoluble in the citric, and even in the sulphuric acid, under any circumstances in which it is safe to apply them to the cloth. Where a delay in printing, however, is unavoidable, the work will not suffer much for twenty-four or forty-eight hours, if the pieces be rolled very hard and smoothly upon the wooden shell, from which they are printed by the printing machine.

It is obvious, from the foregoing remarks, that the success of this operation, so far at least as good whites are important, depends much upon the mordant being as free as possible from the peroxide of iron. On this account it will be found better to prepare the iron liquer for this purpose by using a large excess

of clean iron turnings, and stopping the solution as soon as the liquor has acquired a specific gravity of 12° T., instead of continuing the process till it stands at 18° , and afterwards reducing it by water to 12° T., as I have already directed for the preparation of this mordant for other purposes; in this case, probably less of the iron is peroxidized and the large excess of acetic acid holds that which is peroxidized in solution, and prevents its deposition on the cloth. The pyroligneous acid should have a specific gravity of 7° T., before the iron is added. The Campeachy logwood is decidedly superior to the St. Domingo and Bay of Honduras logwood, for this, as, indeed, it is for every other style of work, in which a good black is wanted.

Some calico printers use a small portion of glue in the logwood dyeing bath, but it is quite useless; it was originally introduced under the idea that logwood contained the tanning principle, which is precipitated by gelatine; but this opinion is controverted by Dr. Bancroft, and I can affirm from repeated trials on a large scale, that it is unsupported by facts.

Very recently the idea of substituting the dry extract of logwood for the wood has been revived, and the article is now imported to a considerable extent for the use of dyers. I have made a few trials of this article, and with good results as to colour, but have not found it more economical in use than the wood. Dr. Bancroft says that where the decoction of logwood has been speedily evaporated, the extract is soluble in water and in alcohol; but where the inspissation has been effected slowly by exposure to even a hot summer atmosphere, the colouring matter will absorb oxygen, become insoluble in water, and that the colours dyed from it will prove much more fugitive than those produced by the decoction when recently made; and observes, that having once attempted to substitute the dry extracts of various dyeing drugs, for the drugs in their natural state, and such attempts having, in almost every instance, been attended with disappointment and loss, by reason of the changes to which colouring matters are liable by the operations necessary for their extraction, cautions those who may be disposed to similar undertakings.

Crimson Figures on a Black Ground.

If the cloth padded with the iron liquor be dyed up before printing and afterwards printed with a thickened solution of the muriate of tin, and simply washed, we have a beautiful crimson instead of white figures on the black ground. In this operation the protoxide of tin is converted into a peroxide at the expense of the peroxide of iron, and is precipitated upon the calico in combination with the colouring matter of the logwood, while

the muriatic acid of the tin combines with the protoxide of iron, forming a soluble salt, which is washed away. From four to six ounces of crystals of muriate of tin *per* gallon will answer this purpose. Thicken with starch. The temperature of the printing stoving room must not exceed 140° or 150° Fahr.

White Figures on a Red Ground.

Pad in old red liquor at 12° T., at a temperature not exceeding 180° Fahr. The liquor should be thickened with one-thirtieth part of *gum red*. Age two or three days, and then print on the same discharge as for *black and white*, only the citric acid at 20° T., will generally answer, unless the patterns on the roller be very fine. The goods should be dunged three times for this style: first, at 165°,—second, at 140°, and, third, at 130° Fahr., and twice dyed in madder.

Black and White Figures on a Red Ground.

Print on the padded red ground before dyeing by a two-coloured printing machine, one roller in the acid paste of the last style, and the other in iron liquor at 18° T., thickened with flour:—Age seven days, and dung three times, and dye twice in madder, using at each dyeing four pounds of the best Dutch crop, or five pounds of the best French madder with two ounces of sumach. The first dunging in this style should be at a temperature of 170° or 175° Fahr., to prevent the black from starting. The black obtained in this way is not good, as the madder is shared between the aluminous and iron mordant, and produces a dark chocolate rather than a black. The cheapness of the style is its principal recommendation. Where a good black is required on a madder red ground, the black should be first printed and dyed up, and the cloth afterwards padded and dyed for the red; the reverse operation cannot well be done and obtain a bright red, because the loosened iron mordant will be liable to fix to some extent on the red ground in the dyeing bath. When the style of printing is such as to require the black to be applied last, it is usually printed in chemical black by the block or surface roller.

White Figures on a Chocolate Ground.

This style is conducted on the same general principles as those of the white discharges on black and red grounds. The pieces must be printed immediately after padding, as in black and whites, and for the same reason, then aged 7 days, and dunged and dyed as for the red ground, except that the dunging must be conducted at a higher temperature, and particularly the fly dunging, which should be at 180° Fahr. The aluminous and iron mordant must

be proportioned to the shade required. The pieces padded, printed, and dyed in this style, are frequently partially blocked, or padded afterwards in the aluminous mordant, and dyed up in quercitron bark; in which case a part, or all, of the figures are made yellow.

White Figures on a Bronze Ground.

The method of producing a bronze ground has already been described under the head of *bronze colour*;—for the discharge, take two pounds of crystals of muriate of tin, and dissolve in one gallon of water, and thicken with British gum;—print for a discharge and wash. Nearly as good a result may be obtained by printing a discharge made by dissolving three pounds of protosulphate of iron, and four ounces of sulphuric acid in one gallon of water, and thickening with flour or British gum.

The rationale of the action of these two salts on the bronze from manganese, is the same: take, for illustration, the protomuriate of tin,—the protoxide of this salt abstracts a portion of the oxygen from the manganese, becomes itself converted into a peroxide of tin, and reduces the peroxide of manganese to a protoxide; in this state the excess of acid of the *muriate of tin* combines with the protoxide of manganese, forming a *soluble salt*, and the remaining acid remains in combination with the peroxide of tin, and both salts are dissolved out.

The bronze from manganese may also be discharged by the oxalic, and even by the tartaric acid, but the former is too expensive, and the latter requires several weeks exposure to the air, to complete the discharge.

Buff Figures on a Bronze Ground.

After printing the super-sulphate of iron upon the bronze from manganese as above, winch the goods in lime and potash liquor, as for raising buffs.

Chrome Yellow Figures on a Bronze Ground.

Pad and raise the bronze as before directed, then take 1 gallon of water, 4 lbs. of nitrate of lead, 2 lbs. of tartaric acid, and 2 lbs. of crystals of permuriate of tin; dissolve the nitrate of lead and tartaric acid in the water, thicken with gum Senegal to the required consistence, and then add and stir in the crystals of tin; print on this colour, and when the cloth is dry run it through a weak solution of chloride of lime; then wash well, and winch the cloth in a solution of the bichromate of potash, allowing two ounces to the piece,

In the foregoing process, the manganese is discharged by the protomuriate of tin on the principle already explained above; the

nitric acid is neutralized by the lime of the bleaching powder, and the chlorine peroxidizes the manganese of the ground. The tendency of the nitrate of lead to crystallize unfits it for this purpose; the tartrate of lead being very insoluble in water, is equally unsuited for this use; the tartrate is, however, soluble in nitric acid, and in this state it exists in this discharge.

Yellow, Pink, Purple, and Blue Figures on a Bronze Ground.

The yellow is produced as in the last. The red or pink, is the *spirit red*, or *peachwood*, *wash-off pink*, and the purple, the *spirit purple*, (vide chemical colours,) with the addition of from one and a half to two pounds of crystals of the protomuriate of tin to each gallon. The protomuriate in these cases, discharges the oxide of manganese, and the permuriate fixes the colouring matter of the peachwood and logwood. The blue is produced by dissolving Prussian blue, (more or less, according to the shade required,) in a solution of the protomuriate of tin, of two pounds to the gallon. All these colours should be thickened with starch, or, what is preferred, gum tragacanth. Some printers substitute the *cochineal pink* for the peachwood pink, in which case a deeper colour is produced. The pink, purple, and blue, in the above, are necessarily very fugitive; but, the great beauty of the style has nevertheless secured it a great sale.

Yellow Figures on a Turkey Red Ground.

Print on the dyed Turkey red ground a paste composed of two and a half pounds of nitrate of lead, and five and a half pounds of tartaric acid dissolved in one gallon of water, and thickened, for the block, with five pounds of pipe-clay and one and a half pounds of British gum, for the cylinder with British gum only; print and hang in a warm room for an hour or two. Make a solution of the chloride of lime of a specific gravity of 10° to 13° T. at 60° Fahr. Warm this to 75° Fahr.; hook the pieces on a frame, so as to expose a smooth and even surface, and dip them in this liquor, taking care to fetch up by raking a little mud, or sediment, from the bottom of the cistern, when the goods are entered, and to move the frame in this liquor all the time it is immersed, which may be about three minutes; then remove the goods quickly to the rinsing cistern, and thence to the wash wheel. After the pieces are washed and squeezed, but while yet wet, winch them fifteen minutes in a solution of bichromate of potash, allowing two ounces for a piece.

In this operation, there is first a double decomposition of the tartrate of lead and the chloride of lime; the tartaric acid of

the tartrate of lead seizes the lime, and liberates the chlorine; the oxide of lead is deposited upon the cloth in an insoluble state, and the chlorine combines with and blanches the colouring matter on the cloth;* secondly, the chromate of potash is decomposed by the superior affinity of its acid for the protoxide of lead, with which it unites, and forms a chromate of lead, which is the same in composition as the beautiful pigment called *chrome yellow*.

This style of discharge work cannot be practised on common madder reds, owing to its severity on the colour generally; and, without the greatest caution, even the Turkey red ground will suffer materially in the discharging process: to prevent this, there should be allowed as little excess of chlorine as possible in the liquor. The excess of chlorine may be neutralized, either by using an additional quantity of lime, or by adding to the liquor a little potash, or soda; by which last means we in fact form a chlorate of soda, or potash, as far as it goes. My own experience in this process having been confined for the most part to trials and experiments in a small way, I cannot say with confidence whether the lime or alkali should be preferred. If an excess of lime be used, the cistern should be well raked, or agitated, during the immersions, as already directed. The immersion should never exceed five minutes, nor the temperature 100 Fahr. Instead of dipping on frames, an arrangement similar to that for fly-dunging and raising buffs, may be advantageously substituted, where much of this work is done.

Black and Yellow Figures on a Turkey Red Ground.

The yellow is the same as the last: the black is a chemical black, printed on after the discharge and chroming processes are completed.

Yellow Figures, on a Drab or Olive Ground.

Take one gallon of aceto-sulphate of alumine, or red liquor, and thicken with three and a half pounds of British gum, and three to four ounces of tallow. Dissolve the zinc in the red liquor, and beat in the gum while cold; then warm the mixture to about 160°, add the melted tallow, and stir till the ingredients are well incorporated. Print with the block, and then pad the cloth with the drab, or olive, mordant, as the case may be, and, after suitable age, dye in quercitron bark. The thickening will be found to resist the action of the padded mordant, and the printed parts will exhibit a bright yellow when dyed.

* The nitric acid, which held the tartrate of lead in solution, is also neutralized by the lime.

Some colour-mixers add to the above resist, four ounces of sulphate of zinc, and half a pint of berry liquor: but these additions are entirely unnecessary; the former is, indeed, perfectly absurd, and has crept into use from a vague idea of the principle on which it operates as a resist in the blue vat. (See "*resist reds*" and "*resist yellows*."

Chrome Discharges.

The chromic acid has recently been discovered to possess the same, or a similar property, for discharging most vegetable colours, that is possessed by chlorine.

If calico be dipped blue in a common indigo vat, and, after drying, padded in a solution of bichromate of potash of two pounds to the gallon, neutralized with two pounds of soda, and dried a second time, white figures may be produced upon it, by printing on the following discharge:—

1 gallon of gum water, at 36° T.;
3 lbs. triple aqua fortis at 74° T.

Mix intimately, and print with the block. If the printing be done with the cylinder, five pounds of tartaric acid, thickened with gum Senegal, or British gum, will answer best; some use sulphuric acid with the tartaric acid, but its liability to act on the roller and doctors should forbid its use in any considerable quantity.

If nitrate of lead be combined with the discharge of nitric acid, we have yellow figures on a blue ground. In like manner most other vegetable colours may be discharged. I have not known of its being applied to the discharge of the Turkey red, and suspect it would not be sufficiently powerful.

The following beautiful style of printing with a chrome discharge, is of recent introduction.

Print a common reserve paste, and dip a light blue in the indigo vat. Then prepare the cloth with an alkaline solution of the oxide of tin, and fix it as directed in the preparation of cloth for steam colours. Print any steam colours that may be desired in the rainbow form, and steam. Dip Saxon blue with the acetate of indigo.* Pad with the bichromate of potash, as above directed. Lastly, print with the following discharge:—

1 gallon of gum water, at 36° T.;—

* The acetate of indigo is formed by adding to every pound of the concentrated sulphate of indigo three pounds of acetate of lead; the decomposition is almost instantaneous. The indigo is transferred to the acetic acid, and the oxide of lead to the sulphuric acid, which falls to the bottom. Decant the clear liquor for use.

4 lbs. nitrate of lead;
3 lbs. triple aqua fortis, at 74° T.

No farther operation is required, but simple washing. I need scarcely observe that the goods should be dried between each of the foregoing operations, and aged, where the nature of the mordants require it.

Some printers add to the above discharge $\frac{1}{10}$ part of a solution of muriate of iron, at 70° T., with the view, probably, of deoxidizing the indigo, and thereby promoting the discharging process.

Mixed Colours.

Under this head may be noticed some of the numerous effects produced by one colour falling upon another, as they occur in the successive operations of calico printing, whether they are the result of chemical changes, or simply of mixture alone.

A black is affected by no other colour, unless it operate as a discharge upon it.

A slight tinge of yellow gives to a deep red a scarlet hue.

Pale reds and yellow produce various shades of orange.

A blue falling on a yellow produces various shades of green, according to the depth and proportions of each.

A blue falling on a strong red produces a chocolate, or deep plum colour; on pale reds various shades of plum, purple, and what the printers call a bloom, according to the depth of each of the constituent colours.

A drab, purple, or buff (from iron) falling on a yellow, forms various shades of olive.

A drab, purple, or buff (from iron) falling on a red, different shades of chocolate.

A yellow, falling on a chocolate, a brown, or snuff colour.

The foregoing remarks are more strictly applicable to what are usually termed fast colours; but, even in that class, there will be found many exceptions, which are noticed and explained in various parts of this article.

DIPPING.

Dipping, in *Calico Printing*, comprehends a variety of processes for applying, or fixing, the indigo dye upon the cloth.

It appears that there are plants, the products in various parts

of the world, during the fermentation of which a green substance is either formed or evolved, which, when combined with oxygen, forms a permanent blue dye. This substance, combined in different degrees with vegetable and mineral impurities, is the indigo of commerce. The immense supplies for the arts, in England and America, are now, for the most part, derived from India, and known by the name of *Bengal* indigo. The price of indigo, at the present time, (1830,) ranges from one to two dollars per pound. If the samples in the market be subjected to an accurate analysis, there will be found a corresponding variety in their intrinsic value. As this is one of the most costly drugs in use, it is a matter of great importance to the dyer to be able to have some method of determining the relative value of different lots in the market: without this knowledge, let the skill of the dyer be what it may, a fortune may be speedily lost in operations on a large scale. Dealers in indigo are generally governed in their purchases by the colour. In this respect, all the varieties met with in the market are referred to three classes,—the *blue violet* and *coppery* coloured indigo; of these the blue is considered the finest and most valuable. We have the best example of this colour in the Guatimala or Spanish float indigo, now become scarce; but we observe it also in the finer descriptions of Bengal indigo. The second quality is the violet coloured, and the third and lowest quality is the copper coloured; the coppery hue is observable on rubbing two pieces together.* Between these well marked classes there is found almost every variety and gradation, and considerable experience is requisite to determine with much precision the relative value of different lots. The foregoing descriptions are intended to apply to the foreign indigo, known at present in our market, and particularly to the Bengal indigo. There is a species of indigo, occasionally met with in this market, and manufactured in South Carolina or Georgia, of a very inferior quality. It is in smaller cakes than the Bengal, of a dirty blue colour, and cannot be made to assume the coppery hue by rubbing: this article is greatly inferior to the lowest qualities of the East India indigo.

Another method of determining the comparative value of different samples of indigo is by throwing a few grains of each upon a red hot iron plate; the indigo will sublime in purple fumes, and the residual ashes on the plate is a tolerable measure of the comparative impurities of each.

* "When the first of these is sold for 9s. (sterling,) the second is commonly thought to be worth 7s., and the third 5s. 6d."—Vide Bancroft on Colours, vol. i. p. 143.

If a given weight of indigo be finely pulverized, and digested, first in forty or fifty times its weight of boiling water, then in alcohol, and, lastly, in muriatic acid, and afterwards be carefully washed and dried, the diminution in weight will indicate very accurately the amount of impurities. The indigo, thus treated, should sublime without residuum when thrown upon a heated iron plate.

Another means of determining the value of commercial specimens of indigo is the reverse of that described for testing the value of the chloride of lime, in treating of the manufacture of that article in this work.

There is but one solvent of indigo in its blue state, and that is the highly concentrated sulphuric acid. In order to accomplish this, the usual method is to take four pounds of the best oil of vitriol, and mix it with one pound of indigo in very fine powder; a considerable degree of heat is excited, with evident chemical action; the solution, if examined in a small glass tube during the process, will exhibit first a yellowish, and afterwards a deep blue colour; there is, during the solution, a slight production of carbonic acid, and of sulphurous acid fumes. The solution will go on without the addition of external heat, though it is quickened by that of the hot water bath. After the process is completed there remains a small deposit of sulphate of lime and other impurities, insoluble in sulphuric acid. The solution is nearly black, but when largely diluted with water, assumes a deep blue colour. So intense is the colouring matter of this concentrated liquid, that the solution is perceptibly coloured when diluted with 500,000 times its volume of water. This is the celebrated Saxon blue of the dyers. The choice of the acid employed in making the Saxon blue is a matter of great importance; it should have a specific gravity of 1.850 or 170° on Tweedale's scale. The makers of oil of vitriol, for this purpose, should reject in the distillation that acid which comes over first, and is contaminated with nitrous fumes, and reserve for this purpose only the most pure. It would be well worth their while to do this, and charge a higher price for it, as the presence of nitric acid is destructive to the indigo. On the Continent the glacial oil of vitriol only is employed. It is distilled by a great heat from the green sulphate of iron, and was formerly the only way in which this acid was obtained. It is more expensive, but the great value of the drug, upon which it acts in the preparation of the Saxon blue, renders it ultimately more economical. The manner in which the solution is conducted is also of importance; it is not advisable to add the whole of the indigo at once; it is best to take the full proportion of acid at once, and add the indigo by degrees, at intervals proportioned

to the violence of the action. It generally requires about twelve hours to complete the solution of one pound of indigo in four pounds of acid. This process may, however, be expedited, and the labour of grinding the indigo be saved by adding the indigo at once in lumps of the size of chesnuts; the solution then goes on more slowly, but as effectually as by the former method.

The Saxon blue solution was considered by Dr. Bancroft, and by most writers since his time, as a sulphate of indigo, or a compound formed by the direct union of sulphuric acid and indigo. This view of its constitution seemed to accord with the fact that, if the acid of the solution be saturated by an alkali, a blue precipitate is thrown down, and the solution becomes clear; it is, however, at variance with the fact that the precipitate thus formed will not, when dry, sublime by heat like pure indigo, and has, in fact, lost every property peculiar to the indigo before it was dissolved, except colour; it is also directly at variance with the facts observed by Berthollet; and more particularly examined and pointed out by Mr. Crum, in an admirable paper on the analysis of indigo, published in the *Annals of Philosophy* for January 1823, that the sulphates of potash and soda, and, indeed, most neutral salts, produce exactly the same effect, and that magnesia does not precipitate the solution at all, although it neutralizes the acid, and that the precipitate, when formed, is itself soluble in water. Mr. Crum has shown that, if pure sublimed indigo be employed, instead of the indigo of commerce, in the solution in sulphuric acid, there is no production of sulphurous or carbonic acids, nor absorption of air during the solution, and infers that there can be no oxidation of the carbon, or hydrogen, previously existing in the indigo; and since there is no gas evolved, and no carbon deposited, he concludes that the nitrogen in the precipitate exists in the same proportion to the carbon that it does in the indigo. From the foregoing, and similar facts, Mr. Crum very justly infers that the Saxon blue liquid is not a chemical compound of indigo and sulphuric acid; that the only operation of the acid in the dissolution of the indigo is to abstract a definite portion of combined water from the indigo, by which it is converted into a new and peculiar substance, soluble in sulphuric acid and water, which he has called *Cerulein*.*

The method of using the Saxon blue, in dyeing, is extremely simple: nothing more is necessary than simply to immerse the cloth or yarn in the liquid, sufficiently diluted, and after the requisite shade is obtained, to allow it to drain, and afterwards

* Mr. Crum's paper on the analysis of indigo may also be found in the notes to the 2d vol. of Dr. Ure's Translation of Berthollet's "*Elements of the Art of Dyeing*."

wash in water, and dry. Several writers have recommended the addition to the vat of potash, lime, or carbonate of lime; and others, to prepare the cloth, previously to immersion, with alum and sulphate of lime;* but these practices are now generally abandoned.

Unfortunately, this colour is by no means a fast one, and is now seldom used for a blue, only except upon woollens. Its use in dyeing the beautiful, but fugitive colour, called *Saxon* or *French green*, is described under that head in this work.

The Blue Vat.

To fix indigo permanently upon calico, a more complex process must be adopted. Before I proceed to describe the method of sitting the blue vat, I think it will contribute to a better understanding of the subject to describe somewhat particularly the constitution and habitudes of indigo in relation to the different agents employed along with it in the various processes of calico printing. Indigo appears to be a compound of a peculiar vegetable principle, which, in the natural state, is colourless and oxygen, and affords one of those striking examples in which chemistry abounds, of the entire change of properties produced on the elements of a compound on entering into chemical combination; here are two colourless substances, which, when chemically united, produce one of the most intensely coloured compounds with which we are acquainted. The proofs of this view of the constitution of indigo are numerous and conclusive. If the juice be expressed from the fresh leaves of the indigo plant, and applied to bleached calico, a green stain is first produced, but on exposure to the air it soon becomes changed to a blue; the same thing happens if the expressed juice be allowed to remain of itself exposed to the air, or to an atmosphere of pure oxygen gas. That the absorption of oxygen is the cause of this remarkable change in the colour of the vegetable matter is evident from the fact, that if the agency of the air and oxygen from other sources, be excluded, no such change takes place, and that the oxygen thus absorbed has entered into combination with a vegetable principle or principles, and actually constitutes an ingredient in the indigo, may be clearly proved by the fact, that the oxygen thus united with the vegetable matter, may be abstracted from it, and made to enter into combination with another body, and that the indigo thus robbed of its oxygen will be reconverted into its natural green or colourless state†. These facts

* Vide Bancroft on the Philosophy of Permanent Colours, vol. i. p. 171, 2.

† The base of indigo as it exists in the plant, is no doubt perfectly colourless, and with great care, the indigo of commerce may be so perfectly deoxidized as

may be most conveniently illustrated by operating on a few grains of the indigo of commerce; pulverize twenty or thirty grains of indigo; introduce it into a phial, and fill the phial two-thirds full of water: on stopping the phial and agitating the mixture, a slightly bluish tinge is imparted to the water, but no diminution of the indigo is perceptible; add to the mixture a few grains of potash, and agitate again; no part of the indigo is dissolved: indeed, to all practicable purposes, it may be said to be completely insoluble in water or in a solution of potash in its blue state; now add to this mixture some substance which has naturally a strong attraction for oxygen; such a substance is the protoxide of iron as it exists in the protosulphate of iron; introduce then into the phial as many grains of this salt as you have done of indigo, and agitate the mixture; in a few minutes the indigo will have lost its blue colour, and have acquired that of a bright green, and become dissolved in the solution of potash; if the same experiment be made with the exception of leaving out the potash, the indigo will in like manner be changed to a green, but retain its insolubility in water. The true explanation of these appearances is this; the protoxide of the sulphate of iron has a stronger attraction for the oxygen of the indigo than the vegetable matter has, with which it is combined; the consequence is, a transfer of the oxygen from the indigo to the metallic protoxide, which is, by this accession of oxygen, changed from the state of the protoxide to the peroxide. The same effect is produced upon the indigo; if, instead of the protosulphate, the hydrated protoxide of iron be used as it is precipitated from the sulphate by the addition of an alkali to the solution. The protoxide of tin either in its separate hydrated state, or combined with the sulphuric or muriatic acids, has the same effect in deoxidizing indigo. The deoxidized indigo of the blue vat is ordinarily green, but when perfectly pure indigo is operated upon by the protoxide of tin, and the deoxidizing process has been most complete, the indigo when precipitated from its alkaline solution by muriatic acid, is nearly white or colourless. The usual light green is probably owing partly to the presence of a small portion of the oxidized indigo combined with some foreign yellow matters in the drug, and partly to the presence of a portion of the hydrated protoxide of iron. That this change in indigo from the blue to a green, or a colourless state, is owing to an abstraction of oxygen, is most satisfactorily proved by synthesis as well as analysis; if a current of oxygen gas, or atmos-

to appear so; but it is so rarely that we obtain it in this state, that the green or imperfectly oxidized indigo is frequently spoken of as the perfectly deoxidized or natural state of the article.

pheric air, be passed through the green solution of indigo, an absorption of oxygen takes place, and the indigo is instantly precipitated in its blue insoluble state; this deoxidation and oxidation of indigo may be alternately performed a thousand times without subverting or altering its nature, showing a stability of composition scarcely inferior to that of mineral substances. The deoxidation of indigo may also be effected by mixing along with it vegetable matters, such as madder, sugar, wheat, bran, &c. During the process of fermentation there is a great demand for oxygen for the production of carbonic acid, and if indigo be present this oxygen is obtained from it. Fermentation is, however, never resorted to in the dyeing of cottons in calico printing. It is applicable principally to the woollen dye.

It will be borne in mind, that in all cases, in order to effect the speedy deoxidation of indigo, an alkali should be added to the indigo, together with the other ingredients, but that this agent is in no respect efficient in the deoxidizing process strictly so called; it only facilitates the operation by dissolving as soon as produced, the green indigo, and thereby preventing its operating as a mechanical obstruction to the deoxidizing agent as it respects the remaining portions of blue indigo. Lime and magnesia have the same solvent power over deoxidized indigo as the alkalis have; the former is extensively used in blue dipping. I shall have frequent occasion in the course of this treatise to advert to the theory of the operation of various agents upon indigo: sufficient has been said to prepare the reader for a better understanding of the process of

Setting a Blue Vat.

To a vat containing about 900 gallons of water, add

60 lbs. of indigo, ground very fine;
100 lbs. of green vitriol, (protosulphate of iron;)
120 lbs. of quicklime in fine powder.

It is of no importance, although some have thought so, which of these ingredients is put first into the vat. The lime should be slaked and sifted previous to putting it into the vat, or, what answers an equally good purpose, and saves much trouble, may, after slaking, be mixed with water to the consistence of cream, and after waiting a moment for the flint stones or other hard bodies to subside, be added to the vat.* Some printers prefer dis-

* The most perfect way of reducing lime to an impalpable powder, is by throwing it cautiously into boiling water; the heat occasions a violent ebullition, and the violence of the action reduces the lime to a degree of fineness almost equal to that of a precipitate.

solving the copperas in a small quantity of hot water before adding it to the vat; to this there is no objection, provided it is not subjected to long ebullition, which has the effect to peroxidize the salt, and render it totally unfit for its office in the vat.

The proportion of lime above directed, is far more than is necessary to decompose the whole of the iron, (as, indeed, it should be.) Two hundred pounds of sulphate of iron require only 41 lbs. of lime for this purpose. It is impossible, therefore, that any blue vat prepared in this way, should ever have iron in solution. The whole of the sulphate must be decomposed within five minutes after the agitation commences, and no change which ever takes place afterwards, can ever make it soluble again; the apprehensions, therefore, entertained by many dyers, of there being too much copperas in a vat, is perfectly groundless. When the ingredients of the vat are all in, it is desirable to agitate them a few moments in order to ensure a complete solution and mixture; but as the indigo and oxide of iron are both undissolved at first, and can only act when in absolute contact; they ought to be permitted to subside and remain as near each other as possible; in this state the protoxide of iron deprives a portion of the indigo of its oxygen, and the lime dissolves it; the vat is again stirred up in order that the dissolved indigo may be diffused through the water, and thus, by alternate agitation and rest, the process is carried on until all the indigo is dissolved, or the solution is as strong as is wanted. The vat should be well raked three or four times a day for two or three days, when, after being allowed to settle for ten or twelve hours, it will be fit for use. The commencement of the solution of the indigo is indicated by the liquors assuming, when the vat is raked, a dark green, and its surface breaking into blue marbled veins; when the solution is complete, the liquor is of a greenish yellow, and the marbled appearance of the surface is very beautiful, exhibiting in quick succession almost every colour of the solar spectrum, and terminating in a deep blue. These changes of colour bear a striking resemblance to those attendant on the oxidation of several metals when in fusion and to steel at a lower temperature, when exposed to the air, and are undoubtedly attributable to the same cause.

The repeated agitation to which the blue vat is necessarily subjected, has a tendency to restore oxygen to the indigo, and reconvert it into the insoluble state; the mere exposure of the surface of the vat to the air, even without any agitation, would in time subvert the constitution of the vat; it is sustained in direct opposition to strong chemical affinities, which are constantly tending to change it; the indigo is continually acquiring oxygen, and the lime carbonic acid, from the atmosphere:

were no indigo taken out of it, the vat would gradually lose its power, the indigo would be revived, (oxidized,) the protoxide of iron converted into the peroxide, and that portion of lime, which had not become a sulphate by combining with the sulphuric acid of the copperas, would become a carbonate. Owing to this tendency of the indigo in the blue vat to attract oxygen, and return to the blue insoluble state, the common manipulations of winching, or working the cloth in the liquor, as practised in other dyes, will not answer in this, for those parts most exposed to the action of the air would attract most oxygen and give the cloth an uneven colour: to avoid this, the cloth is stretched evenly by the selvages and attached by tenter hooks to wooden frames, so that every part of it may be equally exposed to the liquor when the cloth is immersed in the vat, and to the air when it is withdrawn from it. The cloth being thus arranged, is suddenly immersed in the vat, and in a short time becomes penetrated with the green solution of indigo; when lifted from the liquor it has the colour of the solution, a yellowish green, but by exposure to the air gradually attracts oxygen, and assumes the proper blue colour of indigo. A portion of the indigo penetrates the fabric, and, while there, attracts oxygen,—becomes insoluble in water, and permanently fixed in it. Whether this union of indigo with the cotton is to be regarded as a ternary chemical compound of the green matter of indigo, oxygen, and cotton, or as an intimate mechanical mixture, has not, to my knowledge, and, probably, could not easily be ascertained. Much of the indigo which is withdrawn from the vat with the cloth, runs back into the vat, and, for the most part, in a revived, or oxidized, state, and it is possible, that the same particle of indigo may be deoxidized and dissolved, revived, and precipitated a thousand times before it is ultimately combined with the cloth; if the oxide of iron and lime, therefore, were accurately proportioned to the deoxidize-ment and solution of the indigo in the first instance, they become feeble in their action before the vat is exhausted, and, after every day's work, a small proportion of copperas and lime should be added, to repair the waste, and care should be taken that the vat is deep enough to permit the exhaustion (i. e., to the point at which it is found profitable,) of the indigo before the sediment rises to the bottom of the frame.

The choice of copperas for the blue vat is a matter of great importance. It is well known to chemists that there are two distinct sulphates of iron, one of which is particularly adapted to the deoxidizement of indigo, and the other of no use whatever, and yet these two kinds are found more or less mixed in the copperas of commerce. The salt wanted by the blue dip-

per is the persulphate, or green vitriol, whose pale green crystals cannot be mistaken for any other. The ochery matter, with which it is usually found more or less mixed, and into which it has, when exposed to air or moisture, a constant tendency to change, is the persulphate, or highly oxidized sulphate; it has already assumed that state which we wish it to acquire, at the expense of the indigo, and is therefore worse than useless, in as much as it has no action whatever on the indigo, and serves merely to add to the sediment in the vat.

The proportions of copperas, indigo and lime, which I have directed, differ from those recommended by Berthollet and Dr. Bancroft; they direct one part of indigo, two parts of copperas, and two of lime; there is the greatest diversity of practice in this respect among calico printers and practical blue dippers; some recommend one part of indigo, one and a half of copperas, and two of lime; others one part of indigo, two copperas, and three lime. A part of this difference is, no doubt, to be ascribed to imperfect knowledge and observation, but more to diversities in the quality of the indigo operated on; some species of indigo contain two, and even three times the quantity of real indigo that others do, and require corresponding differences in the proportions of copperas and lime for deoxidizing and dissolving them. The proportions which I have given above, are such as I have used with the superior qualities of Bengal indigo; for the inferior descriptions of indigo, smaller quantities of copperas and lime will answer. The exact form and size of the vats is not important; I prefer them seven and a half feet in length, three and a half in width, and six and a half deep; they may be constructed of wood, stone, or iron; in England, they are usually made of stone fastened by iron clamps, and cemented with Roman cement; in this country, they are almost invariably constructed of wood; iron vats would be altogether too expensive here, and are rarely used in Europe. Whatever material be used in their construction, the great value of the dye renders it very important that they should be absolutely tight. It has been the usual practice in the United States, to build the blue vats of three inch pine plank grooved together, and joined by strong iron bolts, and to ensure their tightness by sinking them to within a few inches of the top, in the ground, and *puddling* about them in the manner tanners do with their vats. This practice is attended with great risk: it is certain that pine cisterns cannot be made sufficiently tight to hold the liquor, without puddling, and I should hesitate much to trust to so clumsy an expedient as external pressure from a bank of clay to render them so, especially under circumstances in which a leak of considerable extent might not be detected. A sheathing of lead

will make them secure, but it is expensive, and, unless very thick, is liable to be broken in the operation of raking and dipping. The cheapest and best plan, I have found, is to sheathe them on the inside with the same materials, and in the same manner, as the bottoms of ships are sheathed; but, in this case, it is better to locate the dye-house so that the vats may project into an under story, where every part of them may be frequently inspected; it is hazardous to trust to discovering leakages in vats, which are in daily use, by the sinking of the liquid overnight; a leakage near the bottom, which would scarcely be detected, might make all the difference to the printer between a profitable and a losing business.

Reserve Pastes.

It seldom happens that a vat is employed to dye calico a uniform blue. It is more commonly the object of the printer to impress figures upon its surface with a paste, which shall prevent the indigo dye from penetrating its surface, and which shall, therefore, leave a white object upon a blue ground, after the piece has passed through the blue vat. The action of these resists, or reserve pastes is, generally, not well understood. Substances which resist mechanically, such as flour, or gum and water, or a paste of pipe clay, would remain in the vat unpenetrated but a very short time; the paste would gradually soften, and permit the indigo in its green state to reach the part we wish to protect, and the figures would come out of the dash wheel but miserable whites.

Nor would a thickened acid act much better. It would neutralize the lime, it is true, and precipitate the indigo, at first, on the surface of the paste; but there would be great danger of what is called a starting of the paste; that is, there would probably be more acid in the paste than the lime could neutralize, and, owing to the great solubility of acids in water, the effect would be that the acid would trickle down from the paste, and leave a mark in its course of a lighter shade than the rest of the ground.

Wax and resin have often been employed as a resist of the blue vat, and still are, in silk printing; but they will not give a well defined mark, and it is difficult to clear away the wax afterwards.

Oily substances answer, to a certain extent. But the best resists are those substances which form with the lime an insoluble compound, and which, by oxidizing, as well as precipitating the indigo, before it gets through the thickening, prevents its arrival at the calico in such a state as to colour it. Such substances we have in the highly oxidized salts of copper, which

possess, in relation to indigo, qualities diametrically opposite to those of the salts of iron; the protoxide of iron has, as has already been shown, a stronger attraction for the oxygen of indigo, than the green or colourless principle of indigo has, and, under favourable circumstances, seizing this oxygen, reduces the indigo to its green state, in which it is soluble in alkalis, and passes itself to the state of a peroxide; the peroxides of copper, on the contrary, have a weaker attraction for oxygen than the green or colourless base of indigo has, and, yielding up a portion of its oxygen to the green base of indigo, restores it to its blue insoluble state, and returns itself to the condition of a protoxide. This fact is easily shown by adding to a green alkaline solution of indigo a small quantity of a solution of any of the peroxidized salts, or the hydrated peroxide of copper; the colour is instantly changed to a deep blue. The salts of copper are not the only substances capable of affecting indigo in this way; the nitric, sulphuric and acetic acids, precipitate indigo from its green solution, in a blue state, by yielding up a portion of oxygen, with which they are united, and, on that account, have sometimes been used in the composition of reserve pastes: the muriatic acid, on the other hand, which contains no oxygen, precipitates indigo from its alkaline solution in its green state; but the salts of copper are found most convenient, and the sulphate of copper the cheapest. The following formulæ are the best in use.

I. To one gallon of water, (ale measure,) add four pounds of sulphate of copper, and, for the block, thicken with ten pounds of pipe clay, finely pulverized and sifted, two pounds of gum Senegal.—Dissolve the sulphate of copper in the water, and afterwards the gum; then add the solution, by little and little, to the pipe clay, and mix well together.

For the cylinder the above may be thickened with one pound twelve ounces of flour, and five ounces of British gum, (calcined starch;) add seven pints of the solution of sulphate of copper to the flour, and beat the mixture into a paste; boil ten minutes; mix the British gum with the remaining pint of liquor, and add it to the flour paste while hot, and beat them thoroughly together. Some printers would add half a pint of concentrated sulphuric acid to the foregoing, but it will scarcely improve the resisting properties.

II. To one gallon of pyrolignite of lime, (see Pyrolignite of Lime, preparation of,) of a specific gravity, 17° Tweedale's Hydrometer, add four pounds of sulphate of copper.—Dissolve the sulphate of copper in the pyrolignite of lime at a boiling heat,

let the sulphate subside, and decant the clear liquor, which, when cold, (60° Fahr.,) will have a specific gravity of about 33° on Tweedale's Hydrometer. This is an example of double decomposition; a portion of the sulphuric acid of the sulphate of copper seizes the lime of the pyrolignite, or acetate, and the acetic acid, thus set at liberty, combines in turn with the oxide of copper abandoned by the sulphuric acid; the resulting solution is an aceto-sulphate of copper: more sulphate is added than the acetate of lime will decompose, and we have, therefore, a mixture of the acetate and sulphate of copper.

III. To one gallon of water, add four pounds of sulphate of copper, two pounds of acetate of lead, (sugar of lead.)

The salts may be dissolved separately, by heat, in half a gallon of the water each, and afterwards added together; a double decomposition ensues, and, when the sulphate of lead has subsided, the clear liquor may be decanted, as in the last case. The composition of this solution is the same as the last, but, owing to the superior purity of the acetic acid obtained in this way, is preferred by some calico printers; but it is twice the cost, and probably little superior to the last. In both cases the method of obtaining the acetate of copper by double decomposition is preferable to a direct mixture of the sulphate and acetate ready formed, which, however, is often done. The thickening for Nos. 2 and 3, should be similar, for block and cylinder, to that for No. 1. The experienced colour mixer, however, is aware that both the quantity and proportions of the materials used in the thickening must be varied according to the season of the year, or temperature, the delicacy, or coarseness of the pattern to be worked, &c. The two last described pastes may sometimes be improved for the block by the addition of six or eight ounces of linseed oil well beat in.

Many of the old formulas contain alum, but its utility is very questionable. The list of reserve pastes could be very easily swelled to a great amount; but the reader may rest assured that the foregoing will bear the test of experience, and are selected from others, perhaps, equally good, on account of their simplicity and cheapness. They are intended to resist a vat capable of dyeing a deep navy blue ground; where lighter grounds only are wanted, the salts of copper may be proportionally diminished; but the thickening must remain the same. Two, or even one and a half pounds of the sulphate of copper, to the gallon, will afford a paste sufficiently resisting for a sky blue.

For the manipulations in dipping, and the general management of the blue vat, I cannot do better than to transcribe the

following directions from the article "Dipping" in Rees' Cyclopædia, which is evidently written by a person familiar both with the theory and practice of the art at that time.

"The cloth may be dipped an hour or two after printing, if required, but the whites are seldom so good as when kept three or four days. The paste gets hard and firm, part of the acid evaporates, and the solution of copper becomes more intimately incorporated with the cloth.

"Dark blues, in general, require from five to ten dips, or immersions, according to the shade of blue required, or the strength of the vats employed." [Sixty pounds of indigo to a vat containing one thousand gallons of water is the usual strength employed in common blue dipping.]

"If the vats are strong, five, or, at most, six dips, will give a very dark blue, almost black, the intensity of which will be little increased by farther dipping; the labour is greatly abridged by employing strong vats, but the whites are liable to great injury, as the solution of indigo, when concentrated, acts very strongly on the paste. On this account the first vat should invariably be the weakest of the series, and never stronger than is sufficient to produce a full strong blue at seven, or even eight, immersions. The second and third vats may be stronger, and so on to the last, which may be the strongest of all. The number of vats, in a well arranged dye house, must depend greatly on the nature and size of the establishment; eight of 'one thousand gallons' capacity each,' in one line, side by side, form a good series: double or treble that number may be required; but with fewer, a dyer, whose quantity of work is limited, yet various, will find much inconvenience, especially when, by long working, the dregs or grounds have so accumulated as to require a repose of twenty-four hours at least, after raking up, before the vats are fit to work again. Dark blues may be dipped and finished in the same vat, but it is more convenient to pass them in succession through a series.

"When the piece is well hooked, and the frame ready, the vat must be well skimmed before the piece is entered. The surface of the blue vat is always covered with a film of revived indigo, more or less thick, according to the strength of the vat. This film it is necessary to remove before the frame is immersed, otherwise the revived indigo, which is no longer in solution, attaches itself, and adheres to the cloth in patches, producing unevenness in the dye, especially in the first vat. When skimmed the surface of the vat is dark green, but the blue film reappears in a few minutes; it should not be removed, therefore, till the frame is ready for immersion.

"In five or six minutes the cloth has fully imbibed the dye,

and little advantage is gained, in general, by keeping it longer in the vat." [This is not strictly true, the depth of the shade will be increased by allowing the cloth to remain in the vat ten or twelve minutes, but the direction is, on the whole, correct, as a longer dip, particularly in the first or second vat, is liable to soften the paste injuriously.] "The frame is then lifted out and placed slantwise, in such a manner that all the liquor which drains from the piece falls down into the vat again. When taken out the cloth" [ground] "appears of a pale yellowish green, if the vat is weak, but if strong, more inclining to amber," [and the figures blue, from the precipitated indigo on the paste.] "This colour gradually changes, as the indigo, by absorbing oxygen from the atmosphere, becomes revived, and in five minutes the cloth appears uniformly blue; it is then ready for another immersion. Six minutes *in* and six minutes *out* is a good general rule for dipping dark blues, as the cloth will in that time have acquired the full effect of the vat," [see the correction above,] "and *the green will go off* in little more than five minutes, though the vat be very strong. The bottom edge of the piece retains the green hue the longest, because it is *longest* in draining from the liquor; care must be taken, *therefore*, never to immerse a piece till the bottom edge has been examined and found perfectly ready for the dip. The consequence of entering a piece into the vat while the bottom edge is green, is, as might be supposed, that this edge will be the palest, the indigo not having been revived and precipitated upon it equally with the rest of the piece." [The caution and direction inculcated here are important; in addition to the precaution given, the frame, upon which the cloth is hooked, should be inverted after every dip, and airing, so that in the following dip the selvage, which was before uppermost, shall then be the most depending, and so on; without this resort, it is nearly or quite impossible to dye both sides or selvages of the piece of the same shade of colour.

"In dipping dark blues, the first dip is the most important, and, if it fails, the work is inevitably ruined. First, if the vat be too strong, the whites will never be clear and sharp; secondly, if, for want of due preparation, the cloth does not uniformly receive the dye, the goods will scarcely ever be even when finished. Thirdly, if, either from the paste being too strong, or the vat too weak, or not in proper order, the impression *starts*, or runs, at the first immersion, the ground is sure to be freckled and uneven, and the whites bad.

"Against the first source of error, the knowledge of the fact ought to be a sufficient guard; but if unavoidably it should happen that the leading vat is too strong, there is no other remedy than shortening the time of the dip, and keeping the frame in

four or five minutes in lieu of six, till the vat becomes reduced in strength.

“If the paste be too strong; that is, if it contain too much sulphate, acetate, or nitrate of copper, it is liable to start or run in the first vat, especially when laid on in large bodies” [by the block, which is now seldom used:] “this evil, if not too great, may be remedied, by gently moving the frame up and down, during the first two or three minutes after it is entered. It may also arise from the vats being too weak, and, consequently, containing too little lime in solution, and may sometimes be remedied by the addition of more lime. If in spite, however, of the motion of the frame, the addition of more lime, or of greater strength to the vat, the paste still continues to run, it is a sign the solution of copper is too strong, and the quantity must be immediately diminished.” [This starting of the paste is better provided against by the use of a lime vat, into which the frame is dipped, and suffered to remain from three to four minutes before entering the first blue vat. This vat should be richer in lime than either of the blue vats, and, just before using, it should be thoroughly raked up, so as to diffuse as much lime as possible through the vat mechanically, in addition to that which is held in solution. It should be quite milky with lime. The frame may be moved up and down with more freedom in this than in the indigo vat. By this means, a portion of the salts of copper is decomposed, and the oxide of copper is precipitated in an insoluble state upon the cloth. Another capital advantage from this practice is, that the ground is better prepared for the reception of an even dye by the neutralization by the lime of any oily matter in the cloth, resulting from imperfect bleaching, or accidental impurity, and thereby removing a frequent cause of the freckled and uneven appearance of cloth, which has passed through the blue vat. The smallest particle of oil, or any greasy matter, is fatal to an even dye in the blue vat; but other impurities, that would resist, or materially modify, the madder and other dyes, will rarely affect this. The rule is, if the cloth will take water evenly, it will take the blue dye, and not otherwise. The method of proving (as the dyers sometimes call it) the cloth, is this; into the bottom of a box, placed opposite a window, of sufficient width to receive the cloth, fix a small wooden roller near the bottom, and two other rollers two or three feet asunder, near the ceiling of the room, so that the operator may pull the cloth first through the trough, which is filled with water, and afterwards over the rollers, and let it fall upon the floor, between him and the window, in such a way that every part of it may pass successively between the eye and the light; in this way any parts, which resist the penetration of

the water, will be instantly detected, and such pieces should be laid aside, and subjected to an additional boiling in potash, before they are used for this style of work. This trial is, of course, made before printing, and renders it necessary to dry the cloth again, before that operation can be performed. Some printers are so particular about their work, as to subject every piece designed for blue dipping to this test; others content themselves with trying a few pieces out of every bleached lot of 400 to 600 pieces, and, if they appear well, to receive the rest on trust.]

“When the green is gone off after the first dip, the frame is then moved on, and dipped in the second vat, taking care to skim it well before the piece is entered. In this way, after each immersion, the frame is moved on to the next succeeding vat, till it has received the number of dips required. This depends on the strength of the vat, and the shade of blue wanted; but as, during the process of dipping, the vats continually get weaker, the goods, after a certain time, will require an additional immersion, or even two or three, to get them up to the strength of the first pieces that were entered.

“When the goods have received their last dip, and have acquired their full shade of colour, they are taken off the hooks, and well winched in clean water; they are then, by the successive operations of washing, repeated as occasion may require, freed from the paste, and rendered as clear as possible, before going into the sours. Souring is necessary to free them from the last remains of the paste, and give a brightness and finish to the whites. A solution of sulphuric acid, weak enough to be borne in the mouth without inconvenience, is sufficient to dissolve what oxide of copper is left in the cloth after good cleaning. The goods are immersed in this ten or fifteen minutes, after which they are well washed and hot-watered, and when dry are finished, or ready for any succeeding operation. The excellence of this kind of work depends on the clearness and purity of the white, and on the fulness and evenness of the blue.

“When the vats become exhausted by working, they must be refreshed. If a vat contains a tolerable charge of indigo, copperas and lime, and has been worked only once, raking up alone will be sufficient to put it in a state of working again. When again exhausted, copperas and lime must be added to dissolve the revived indigo. The quantity must depend upon the size of the vat, and the supposed quantity of indigo which it contains. From twenty to forty pounds of copperas, and three-fourths of that quantity of quicklime may be added at once to a vat of one thousand gallons, or thereabouts; and some idea may be formed of the effect which this should produce, by recollecting that one pound of indigo requires for solution about

two pounds of sulphate of iron [the writer here follows the directions of Berthollet, who probably operated on a very pure kind of indigo. I have recommended a little less copperas in proportion to the indigo, viz. as 10 to 6.] It is proper always to have an excess of lime in the vat, but it is wholly unnecessary to make those frequent additions of lime without any thing else, which is the practice of many blue dyers. It serves no other purpose but to fill the vat speedily with dregs, which ought to be avoided as much as possible, as, when they are accumulated to a certain pitch, it is necessary either to take them out, or suffer the vat to repose from 36 to 48 hours before it is fit for work after raking.

“If equal quantities of copperas and lime have been used when the vat was formed at first, and three parts of lime added for every four of copperas afterwards, any other addition of lime is wholly useless. Some idea may be formed of the state and condition of a vat by observing its appearance when raked up. In general, if it looks dark green or black, it may be presumed it contains a quantity of revived, or undissolved indigo, and copperas and lime are, therefore, necessary: this blackish appearance may, nevertheless, be occasioned by a very great excess of copperas, or sulphate of iron, the oxide of which, when recently precipitated by lime, is dark green; as this, however, could arise only through great ignorance, or accident, it is not often likely to be the case, as the quantity of copperas required to produce this effect must be very great indeed.

“When a vat rakes up yellow, or very pale yellowish green, it is supposed by some to contain too much copperas, and must be corrected by the addition of more lime. It is hardly correct to say that a vat contains any excess of copperas, since this salt cannot exist in solution with lime. A vat may want lime, and, in this case, it will be very weak,—of a pale yellowish green,—produce a very feeble blue, and the paste will invariably *creep*, to use the dyer’s phrase, or, in other words, will run, and lose the sharpness and smartness of the impression, the moment it is entered into the vat. This may be the case at the time the vat contains a quantity of revived indigo also, and rakes up black, so that no certain conclusion can be drawn from the yellowish appearance aforesaid. If a vat be weak, the froth which forms at the top during raking, is pale sky blue; the surface does not speedily break into marble veins, nor is it soon covered with a blue film. A strong well-conditioned vat, on the contrary, when raked up, becomes covered directly with a permanent and copious froth, the colour of which varies from a deep blue, when the vat is of ordinary strength, to a bright copper colour, which is always characteristic of a very strong solution,

and the surface, when skimmed, is in an instant covered with a thick film of revived indigo. This film, and the deep blue and proper coloured froth, is the best and purest of the indigo, and is called the *flower of the indigo* by the old dyers. In skimming, great care must be taken that this is carefully preserved, and returned again into the vats at the time they are refreshed."

Method of starting a blue Vat.

When a vat becomes so weak as to render the working of it unprofitable a considerable quantity of indigo still remains in it, and the best method of separating it from the dregs, with which it is united, becomes an important problem. Where there is a spare empty vat the ordinary method is to *spring the vat*, as the dyer's phrase is, that is, add such an additional quantity of copperas and lime to the vat as will certainly dissolve all the remaining indigo, allow the sediment to subside, and then bale, or pump off, the clear solution into the empty vat, to which a fresh quantity of indigo, lime, and copperas, may be added, for a new vat. If it be desired to recover the indigo in a solid state, this may be effected either by precipitating the indigo from its solution by muriatic acid, which, uniting with the lime, forms a soluble salt, and the indigo is precipitated in a fine pulp to the bottom of the vat, and which, after pumping off the clear water, and a little stirring and exposure to the air, will become perfectly revived; or, it may be recovered by exposing the solution largely to the action of the air: to accomplish this, it is baled from the vat and poured into wicker baskets placed over the empty vat, and suffered to fall through in streams from a considerable height; this process should be repeated till the liquor on standing shall become clear, or at least free from indigo. When the indigo has subsided, the clear liquor may be pumped or drawn off, and the indigo dried by a gentle heat or in the sun, and, if the object be to ascertain the exact amount of indigo consumed in a given space, carefully weighed. If the indigo be precipitated by muriatic acid, it is very pure, and, probably, from 25 to 50 per cent. richer than the indigo originally put into the vat; if recovered by exposure to the air it will probably contain more lime than when first dissolved; for which due allowance must be made. It requires one ounce of muriatic acid of specific gravity 1.180, to saturate the lime in one gallon of lime water.

It is always preferable to *start*, or clear out the vat, after every charge of indigo is worked up. The accumulated dregs will otherwise impede the operation of raking; upon which the success of the business very much depends. The practice of many blue dippers to allow the dregs to remain till they are touched by the frames in dipping, is slovenly and wasteful.

Protecting, or Mild Pastes.

It is frequently an object with the calico printers to protect madder red, and other delicate colours, from the action of the blue vat; to accomplish this object, a paste is printed over them, which must possess the property of the reserve pastes already described, of neutralizing and resisting the action of the blue dye, and, at the same time, have nothing in itself injurious to the colours thus protected; the common reserve pastes, made from the salts of copper, will not fulfil this last indication, as the oxide has the effect to sadden the colours it is designed to preserve. The salts of zinc are particularly well suited for this purpose:—

Take 1 gallon of gum water at 28° T.;
 2 lbs. of sulphate of zinc;
 5 lbs. pipe clay;
 8 oz. soft soap.

Dissolve the zinc in the gum water, and then add it by degrees to the pipe clay, beating it first into thick paste, and gradually thinning it down till the mixture is perfect; then warm both the pipe clay mixture and the soap, and mix them intimately and strain.

Another.

Take $\frac{1}{2}$ a gallon of gum water at 34° T.; 2 lbs of muriate of zinc, or 1 gallon of solution of muriate of zinc made by saturating muriatic acid of specific gravity of 33° T., with metallic zinc; thicken with pipe clay to the required consistence; it is well enough to make the paste a little too thick, so as to allow the printer to reduce it at his pleasure to suit the particular pattern, by stirring in a solution of sulphate, or muriate of zinc, of the same strength as directed for the paste in the first instance. The quantity of zinc used by different colour mixers is very various, some directing no more than 1 lb., and others 4 lbs. per gallon: something depends on the strength of the blue vat, and the length of the dip; if there be too little zinc, the *resist*, to use the dyer's phrase, will be imperfect; if there be too much zinc, this paste is liable to start, and trickle down upon the cloth and resist the blue dye or parts intended to be coloured. The amount of thickening will require to be varied with the temperature and season of the year. The pastes should be of such a consistence as to penetrate the cloth quite through to the back side; and, in order to judge of the perfection of the printing, it is usual to examine the pieces before dipping upon the back side. Mild pastes are always applied by the block, or, in some rare instances, by the surface roller. The printed pieces should be hung in a warm room at least 12 hours before dipping, and,

where time and room will permit, for a longer time, to give compactness and hardness to the paste. The soap in the first formula, which I prefer, is added, to improve the working properties of the paste; some colour mixers use double and even treble the quantity here directed.

The salts of zinc do not resist the action of the blue vat, on the principle of oxidizing the indigo like the salts of copper, but simply by the mechanical impediment, which the precipitated oxide presents to the penetration of the blue dye; where the sulphate is employed, the sulphate of lime formed upon the surface of the cloth by the union of the sulphuric acid of the zinc with the lime of the vat, an additional obstruction would seem to be presented to the penetration of the dye; theory, therefore, would lead to a preference of the sulphate to the muriate of zinc, though some printers speak in high terms of the latter, which is more recently introduced into the art.*

Where very fine figures, (or *shapes*, as they are technically called,) are required, it is a frequent practice to add from two to three ounces of the acetate, or nitrate of copper, to the foregoing pastes. Nitric acid is sometimes a constituent part in *mild* pastes:

Take 1 quart of nitric acid at 36° T.;
 2½ lbs. of sulphate of zinc;
 3 quarts of water thickened with 2 lbs. of gum Senegal;
 5 lbs. of pipe clay.

Dissolve the sulphate of zinc in the gum water; then add the acid, and, lastly, thicken with the pipe clay, and strain; the effect of nitric acid on the liquor of the blue vat I have already explained in speaking of *reserve pastes*.†

For very light shades of blue, where of course, the dip is short, the following formula may be adopted;—

Take 1 gallon of water;
 4 lbs. of sulphate of magnesia;
 2 lbs. of soft soap.

Thicken with gum and pipe clay as before; the theory of the operation of this paste in resisting the blue vat, is similar to that in which the sulphate of zinc is the resisting ingredient.

* The protecting, or mild paste, may be applied either before or after the mordant is dyed up, the colour of which it is intended to protect from the action of the blue dye. It is as often used in the latter as in the former way.

† Arsenic acid is sometimes used in the same manner and for the same purpose as the nitric acid is in this case.

Mild pastes may be printed over a dyed colour, or over a printed mordant not dyed; in the former case they are printed with narrow blocks, in the latter with wide ones.

Resisting Mordants.

All the colours dyed on the iron and aluminous mordant, and a variety of others, are produced on a blue ground by combining the mordants, or bases of the colours, with the pastes, which resist the action of the blue vat; dipping the pieces, and, after washing, treating them as though the mordant, or bases, had been separately applied to the cloth, and not dipped. The oxide of copper is itself a mordant, and, unfortunately, a bad one, though some account was formerly made of it by dyeing a faint yellow upon it with quercitron bark, as it is deposited on the cloth in the common reserve paste.

Strong Resisting Red.

Take 2 gallons of aceto-sulphate of alumine, (old red,) at 16° T., sightened with peachwood; 10 lbs. sulphate of zinc; 40 lbs. of pipe clay, and 10 lbs. of soft soap; and 8 gallons of the *standard gum red*, (old red.)—Dissolve the sulphate of zinc in the sightened red liquor, then add the solution by degrees to the pipe clay, and beat it into a paste; then add the soap and gum red, and stir till the ingredients are intimately mixed. Strain, print, and hang in a warm room at least 24 hours before dipping.

Another Resisting Red.

Take 1 gallon of standard red mordant, sightened with peachwood, and thickened with 2 lbs. of gum Senegal; 2½ lbs. of pipe clay, 4 oz. of hog's lard; 2 oz. of olive oil; and 2 lbs. of a solution of muriate of zinc, specific gravity of 80° T. Add by degrees the thickened red mordant to the pipe clay, and beat them well together; then warm the mixture, and add the oil and lard; stir well; and, lastly, add the muriate of zinc; mix intimately and strain through a coarse cloth.

Another Resisting Red.

Take 1 gallon of standard red mordant at 16° T.; 4 oz. of verdigris.—Thicken with gum Senegal and pipe clay, as before.

The first of the foregoing formulæ I have found to answer a good purpose on the most extensive scale. The second is very similar, and, in composition, thought to be improved, both in the working and resisting properties, by the addition of the oil and lard, and in the substitution of the muriate for the sulphate of zinc; the last is capable of resisting the blue vat very well,

perhaps better than either of the others; but the acetate of copper is objectionable, on account of its acting as a mordant in the madder dye and saddening the red, and particularly on pale reds.

For paler shades of colour the aluminous mordant may be diluted to any degree required, the other ingredients of the paste to remain the same for every gallon of the liquid mordant. If a deeper shade of blue be wanted than what is familiarly known by the term *sky blue*, the dip must be prolonged, (the strength of the vat being the same,) and the resisting ingredients, that is, the salts of zinc, or copper, as the case may be, must be proportionably increased; but this is seldom required. These pastes are rarely printed by the cylinder; but, where this is the case, the pipe clay must be left out, and the necessary consistence given to the colour by the addition of more gum. It is scarcely necessary to remark that, where paste of a thinner consistence is requisite, the foregoing are to be reduced by a solution of the resisting salts of zinc, or copper, of the same strength as used in the first instance; indeed, it is usual in this, as in almost all other cases, to furnish the printer with a pot of the unthickened mordant to dilute his paste to suit the pattern in hand.

The condition of the blue vat, in regard to strength and proportions of materials, is a very important consideration in this style of printing; more, in fact, depends upon it than upon the exact composition of the paste; an ill conditioned vat is the source of most of the miscarriages with which calico printers are so often perplexed in this branch of the art. A fresh vat, composed of 60 lbs. of indigo, 100 lbs. of copperas, and 120 lbs. of lime, is well adapted for this, and, indeed, for most kinds of *resisting work*. I have sometimes thought that an addition of 4 lbs. of potash improved this vat, and, on the whole, recommend it. If the vat contain too much lime, the margin of the red figure, when dyed up, will appear corroded; or, in the workmen's phrase, *white edged*: if the vat be wanting in lime, or too weak, which is the same thing, (inasmuch as undissolved indigo in the bottom of it is wholly inoperative,) a somewhat similar appearance is produced, though in a very different way; in the first case the lime, or, perhaps, the solution of indigo, *in its compound capacity*, dissolves away a portion of the paste and mordant; in the latter, the vat being weak, and the dip necessarily prolonged, the paste is softened, and, spreading beyond the figure, resists the action of the blue dye on the blue ground; in both cases a white space is observed between the figure and the ground; but, in the former, this is produced at the expense of the printed part, and, in the latter, of the ground; the opinion, therefore, entertained by many printers, that the *white*

edged work is invariably attributable to an excess of lime in the vat is quite erroneous, and calculated to mislead. In addition to the general directions, already given in treating of common blue dipping, for the management of the blue vat, and which apply, in the main, to this style of work also, I would insist strongly on the obvious propriety in all cases, and in dipping the resisting pastes in particular, of making preliminary trials every morning, after the renewal of the vat, by the addition of fresh lime or copperas, as well as after the first *setting*, of its fitness for the work, by dipping slips of the printed goods, and, in the case of the resist colours, even by waiting to see them dyed up before venturing on dipping whole pieces; these precautionary measures necessarily consume some time, perhaps an hour each morning, but they prevent miscarriages and loss; the dipper, who neglects them, let his judgment and skill be what they may, will occasionally meet with severe disappointment. It is advisable never to work this vat so low as in common blue dipping, but when it becomes too weak for this work, either to work up the indigo for other styles, or *spring* the vat and *start* the clear solution into another vat preparatory to receiving a fresh charge of indigo. The immersion of goods printed with resisting mordants in the lime vat, as recommended in dipping common blue and whites, previous to the *blue dip*, must not be omitted.

After dipping, the goods should be thoroughly winched in hot water, and then washed, preparatory to dunging and dyeing. The mordant being precipitated upon the cloth in an insoluble state by the lime, the effect of hot watering and washing, previous to dunging, is not to be avoided, as in goods printed for madder dyeing in the ordinary way; but *souring* the pieces out of the blue vat is inadmissible in mordanted pastes, for an obvious reason, and more particularly in resisting pastes containing the iron mordant, to which these general observations are also intended to apply.

Resisting Chocolate.

Take two quarts of iron liquor at 12° T., two quarts of acetate-sulphate of alumine (*old red liquor*) at 21° T., and twelve ounces of acetate of copper.—Thicken with two pounds of gum Senegal and four pounds of pipe clay. In dark colours, containing more or less of the iron mordant, the acetate, or nitrate of copper may be used without sensibly affecting the shade, and afford a better resisting paste.

Resisting Yellow.

This is the same paste as the first formula given for the re-

sisting red, only it is usual to sighten this with a decoction of the quercitron bark, instead of peachwood. After dipping, &c., dye in the quercitron bark.

Resisting Black.

Take one gallon of iron liquor at 12° T., four ounces of the acetate, or nitrate of copper.—Dissolve the salt of copper in the iron liquor, and thicken with two pounds of gum Senegal and four pounds of pipe clay. Dye in madder.

In like manner, various shades of purples, olive, drab, and other dark colours may be produced, by combining with the pastes the mordants for such shades, and, after dipping, dyeing them in their appropriate baths, as heretofore directed for the same mordants in the madder or quercitron bark, or both combined, as the case may require.

Resisting Buff.

Take one gallon of acetate of iron, prepared from two pounds of sugar of lead and four pounds of sulphate of iron, four gallons of water, seventeen pounds of gum Senegal, twenty pounds of pipe clay, and five pounds of soft soap.—Dissolve the gum in the iron liquor, diluted with the water, then add the mixture gradually to the pipe clay in fine powder; and, lastly, add the soap, previously warmed, and stir till the ingredients be thoroughly incorporated. Print, and after two days' age, dip for a light blue in a vat of the same strength as before directed for resist reds. The moment the goods are withdrawn from the blue vat they should be plunged into another vat of clean water, unhooked from the frame, rinsed by winching, washed in the dash wheel, hot watered, and dashed a second time. The lime of the vat is sufficient for raising the buff in the operation of dipping. If the foregoing operations for cleansing the goods be found insufficient, the pieces may be winched in a weak sours for three or four minutes between the hot watering and the last washing. If the sours be used, at an earlier period in the process, before the iron has become peroxidized, the colour will be liable to be discharged.

This colour, when printed over a madder chocolate, forms a very pretty style, and one in considerable request of late years. The above paste affords a good shade for this purpose, but the iron liquor may be more or less diluted, (the thickening, and other ingredients, remaining the same for every gallon of the liquid,) at the pleasure of the printer.

Another Resisting Yellow.

Take four pounds of sulphate of copper, and two and a quar-

ter pounds of acetate of lead; mix, and dissolve in one gallon of water, and thicken with gum and pipe clay, as in other resisting pastes: print, and hang in a warm room one day; dip in a lime vat for some minutes, to precipitate the oxide of lead upon the cloth, and then in the blue vat, prepared as for resisting reds, according to the shade wanted. If only a very light shade of blue be wanted, it will be necessary to give the cloth another dip in the lime vat to decompose perfectly the nitrate of lead; but if a deep shade of blue be the object, the lime of the vat will be sufficient. The cloth is then rinsed, and washed, and *raised*, as the dyer's phrase is, in a solution of bichromate of potash, as for other chrome yellows.

As the oxide of copper, as well as the oxide of lead, is precipitated on the calico, there is produced a chromate of copper also, and this gives the colour a dull orangy appearance; a slight *sour* in the muriatic acid, diluted with sixty waters, will, by dissolving out the oxide of copper, brighten the colour in a remarkable manner; and, what is of still more importance, gives it a degree of stability of which it has not been thought susceptible.

Another method of producing the chrome yellow on a blue ground is this:—take three quarts of gum water, three and one-half pounds of pipe clay, and four pounds of sulphate of lead, produced in the double decomposition of alum and sugar of lead in preparing the acetate of alumine; beat the whole into a paste, and add by degrees one quart of water, holding two and a half pounds of blue vitriol in solution: mix, print, and proceed in all other respects as in the last case. This is a cheaper process than the last, but differs from it nothing in principle.

Neutral Paste.

This term is applied to a paste, which is intended both to resist the action of the blue vat, and to discharge any mordant which may be printed over it previously to dipping. It contains the elements of the common reserve pastes, and of the acid paste, such as I have already described, for discharging the padded grounds for the black, red, and chocolate-coloured grounds. The resisting materials must be proportioned to the depth of the shade of blue, and the strength of the acid to the mordant to be discharged. Most direct the lime or lemon juice of a specific gravity of 12° T. for reds, 18° for chocolates, and 24° for blacks. I have not observed such wide differences in these mordants with respect to the acid discharges; much more depends upon the strength of the pattern to be worked: a stronger discharge is required for an engraved roller than for the block; and a finely engraved cylinder requires a much sharper

acid than a coarse one. The following formula will be found to answer in most cases.

Take one gallon of lime juice at 18° T., one pound of sulphate of copper; thicken it with five pounds pipe clay, and two pounds of British gum for the block; or with five pounds of British gum for the cylinder. Some prefer a mixture of the sulphate, nitrate, and acetate of copper, instead of the sulphate alone, for the resist; but I think the sulphate amply sufficient for any shade of blue ever required in this style of work. The super-sulphate of potash has also been substituted wholly or in part for the lime juice, and in some old formulæ I find a diluted sulphuric acid alone used for the discharge; but the majority of printers, I think, now prefer the lime or lemon juice alone. The theory of the operation of this paste has already been explained, in speaking of reserve pastes and acid discharges on padded grounds.

China Blue Dipping.

The object in this style of calico printing is the reverse of that of common blue dipping; in the latter the printer's aim is to produce white figures on a blue ground; in the former, to produce blue figures on a white ground; both processes, so far as the deoxidizing, dissolving, and fixing the indigo are concerned, are conducted on the same general principles, and with nearly the same materials.

Take 28 lbs of indigo;
21 lbs of red orpiment;
24 lbs of sulphate of iron (green copperas,) and
8 gallons of iron liquor at 8° T.

Grind the indigo and orpiment as fine as possible, in five gallons of iron liquor, and then add the sulphate of iron dissolved in the remaining three gallons. For a deep blue, dilute this mixture with two parts of iron liquor, and thicken with starch; for pale blues, reduce the standard liquor with iron liquor thickened with gum to the shade required. No ageing of the pieces is necessary after printing; indeed it is better to dip immediately before the oxide of iron becomes peroxidized.

Two vats, therefore, are all that are absolutely required; it will, however, be generally advisable to have three vats for these solutions, two for lime and one for copperas, placed between the lime vats; in this way double the amount of work may be done with the addition of only about fifty *per cent.* in the outlay for vats; but where much work is required in this style, a series of 11, 15, 21, or more will be necessary: the series should constitute an odd number, so as to begin and end

the series with a lime vat; besides these, it is desirable to have a rinsing vat to plunge the goods into after the last dip, and before they are unhooked from the frames. The copperas solution should have a specific gravity of from $4\frac{1}{2}^{\circ}$ to 10° T., and proportioned in some degree to the firmness and weight of the goods to be dipped; at least, this is the utmost range within which good work can be done: with a weaker solution than $4\frac{1}{2}^{\circ}$ T., the shade of the colour will be very faint; with a stronger than 10° T., it will be very liable to be uneven.

The lime vats will require about fifteen pounds of fine sifted quicklime for every one hundred gallons of water, or the same amount of lime may be added in the form of *cream* of lime, as recommended in setting the common blue vat.

The following directions for the management of the dipping I transcribe from an excellent article on this branch of calico printing, in Rees' Cyclopædia.

"When the pieces are hooked and properly arranged on the frame, they are entered first into the lime, and the dipping proceeds as follows:

1.	Entry in the lime vat	5 minutes.
2.	in the copperas vat	30
3.	in the lime vat	10
4.	in the copperas vat	30
5.	in the lime vat	20
6.	in the copperas vat	45
7.	in the lime vat	45

"During the first five minutes in the lime the frame must be gently rocked, or moved up and down, then drawn up and tightened. The vat, both now and at every subsequent dip, is well raked up before the frame is entered. When entered in the copperas vat, rock five or six times, to detach the loose lime from the piece.

"At the second entry in the lime, rock the whole time.

"At the second, and every succeeding entry in the copperas vat, rock five or six times as before, to detach the lime.

"At the third and fourth entry into the lime, rock five or six minutes, and now and then.

"The reason for finishing out of the lime, is to keep the frames and hooks free from the rust and incrustation of the copperas, which it loosens and renders more easy to detach and clean; with respect to raising the colour, it makes no difference whatever.

"When the piece comes from the copperas vat the second time into the lime, it will appear a grass green colour, if there

be a proper quantity of lime in the vat. If too little, the piece will appear yellowish, and more lime must be added.

"Take off the pieces quickly after the last dip, and winch them briskly in the water pit a minute or two at the most." [A proper water vat at the end of the series, as recommended above, into which the pieces may be plunged immediately after the last dip, is preferable to waiting to unhook them from the frame; but in this case the winching cannot be dispensed with afterwards; to keep this water vat as clean as may be, I would recommend that a stream of water be kept running constantly in at the top, while another is running out at an orifice near the bottom, and which will carry off the mud and sediment, and supersede the necessity of an otherwise frequent change of the water.] Get them into the sours, and, after winching over twice, or thrice, let them lie an hour or two, after which winch again four or five times, and wash well in the wheel. Hot water them, and wash again before hot souring, which is done in a sour of specific gravity $2\frac{1}{2}^{\circ}$ T., heated to 180° Fahr. Winch the goods four or five minutes in this, after which, wash, hot water, &c., and finish for drying.

"If the goods are kept too long out of the cold sour after the last dip, the oxide of iron with which they are coated oxygenates very rapidly, and the cloth becomes buff or orange. It is with difficulty that the iron is disengaged, and not without long and very strong hot souring.

"The cold sours soon become foul with the loose superfluous indigo, which is detached, and unfits them for light goods, long before the acid is saturated. In this case it is economical to add two or three shovels full of fine well-beaten clay previously mixed up with water; when this is well incorporated with the sours, and suffered to subside, it carries down with it a great part of the floating indigo, and renders them fit for use again.

"After every day's work, the lime and copperas vats must be refreshed. From twenty-five to thirty pounds of lime, according to the size of the vat, and the number of pieces that have been passed through it, must be added every night. No harm can arise from the excess of lime, excepting the unnecessary expense of more than is required, and the accumulation of sediment, or mud in the vat, which will soon require removing.

"Ten pounds of copperas are generally added for every piece that is dipped. This is suspended at the surface in a wicker basket, till all is dissolved. It is quite unnecessary to rake up the vat, as the fresh additions of copperas will incorporate uniformly without stirring, which, by muddying the vat, may do mischief. Care must be taken to use the hydrometer frequently to correct any deficiency, or excess, which may arise

in the specific gravity of the solution of sulphate of iron. In making new, or fresh copperas vats, after having brought them to the standard on the hydrometer, add, to every thousand gallons, four or five gallons of the lime vat (raked up) and one pound of potash. This is to neutralize the superabundant acid of the copperas. The grass green copperas is the best for this purpose; it contains the least free acid: the pale whitish green is the worst, and when such is used, it will be proper, occasionally, to throw into the vat about one pound of potash; and four or five gallons of muddy lime water.

"When daily worked, the lime vats should be emptied out, and wholly renewed, at least once a month. The copperas vats are never wholly emptied; but when the mud accumulates so as to be troublesome, and endanger the safety of the work by resting on the lower edge of the piece, it must be taken by a scoop or shovel, proper for the purpose.

"The ground of those goods, which show much white, will, in general, be sufficiently clear when finished, according to the preceding directions; the white is, however, greatly improved by a gentle soaping, and one or two days' exposure on the grass.

"In general, better work may be produced in the winter than in summer; in hot weather, the colour is liable to be uneven, patched, and mealy: the cause of this has not been well ascertained, though, in all probability, it arises from the increased action of the sulphate of iron and lime, at an increased temperature; it is not unlikely that weaker copperas vats, would be found to act better in summer than strong ones, as the effect of temperature would thereby, in some degree, be counteracted.

"From the nature of the process of China blue dipping, it must be evident that it must precede any other application of colours to which the cloth is intended to be subjected. If, for instance, reds, or yellows, are to be introduced, these must follow the operations of dipping, as they would inevitably be ruined by repeated immersions in copperas and lime, or wholly discharged by cold and hot souring."

I have said that the operations of blue dipping and China blue dipping are conducted on the same general principles, so far as the indigo is concerned: the latter is, in fact, a topical blue dyeing, and the same changes are effected on the indigo, by the alternate immersions in the lime and copperas vats, as are produced by their mixture in the common blue vat. To begin with the first operation, the indigo is partially deoxidized by the copperas and orpiment, with which it is ground, and the iron liquor also does its part in this way; a portion of the indigo, therefore, enters the first lime vat in the green state, and, being dissolved by the lime, readily penetrates the cloth, the

oxygen of the air in the cloth, and, mechanically mingled with the liquor in the vat, is sufficient to renew the indigo without exposure to the action of the air, as in common blue dipping. This oxidation cannot take place in the blue vat, for the very reason that the deoxidating materials are in constant contact with the indigo. The effect of the first dip in the copperas vat is to supply the indigo with a fresh portion of the deoxidizing material, the proto-sulphate of iron, which is, to a considerable extent, decomposed, and its protoxide precipitated by the lime remaining in the cloth upon the fabric, and in immediate contact with the indigo: the second lime dip again dissolves, and enables the indigo to penetrate the cloth, and so on through the other dips.

Although it is usual, and, as far as I am informed, the invariable practice of calico printers to grind the indigo with copperas or orpiment, or both, yet the propriety of the practice is somewhat problematical; the effect of grinding must, by such repeated agitation and exposure of the materials to the air, have a direct tendency to peroxidize the iron and effect that change upon the orpiment (the acidification of the sulphur) at the expense of the air, which it is the obvious intent of their use to do at the expense of the indigo; and, if any part of the indigo be deoxidized by these materials, as there probably is, the frequent exposure to the air during the tedious process of grinding, must reduce it again to the blue state. I should much prefer grinding the indigo first, and adding the orpiment and copperas afterwards; the former in a concentrated solution, and the latter in fine powder.

Some of the best calico printers in England have, within a few years, discarded the use of orpiment altogether in the China blue paste, and with probable advantage, in as much as the work is fully equal to what it is when it is employed, and with a saving nearly equal to the entire orpiment heretofore used. In such cases, I believe it is usual to substitute the muriate for the sulphate of iron in the paste, and very recently the muriate has been much used by some English printers, instead of the sulphate in the vats, and, it is said, with very decided advantage over the latter.

An improved, or rather a new method, is also recently introduced by the Lancashire printers, of exposing the cloth to the action of the lime and copperas liquors; instead of hooking the piece upon the common dipping frame, the cloth is made to pass over rollers affixed to the frame, which is immersed in the liquor; it differs in nothing in principle from the common arrangement for fly dunging, except that the cloth, on leaving the vat, instead of passing off into a cistern, is wound again upon a

roller, attached to the frame, and the movement is given by hand. This frame is hoisted alternately from the lime to the copperas cisterns, and the reverse; and such a speed is given to the rollers, in either case, as shall give the necessary time of exposure to the action of the respective vats. I know of some printers who have produced excellent work in this way, but the arrangement is more liable to miscarriage than the common frames, and many have failed entirely in their attempts in it, and have gone back to the old method.

The proportions of the muriate, sulphate, or acetate of iron, and of orpiment, if used, employed for the printing paste by different printers, are very various; but it is a matter of very little consequence, within a considerable range, of which the formula given above may be considered as about the medium. If more of the deoxidizing materials be employed, more of the indigo may be fixed upon the cloth permanently before dipping; if less, more will remain to be done in the vats.

Pencil Blue.

Pencil blue, so called from the circumstance that it was formerly applied by the pencil, is another form, in which indigo is topically fixed upon calico. It differs from the China blue in that, in this case, the indigo is completely deoxidized before its application to the calico, and requires no farther operation than simply printing and washing. To preparé this colour,

Take 1 gallon of water;
1 lb. of indigo, in very fine powder;
1 lb. of red orpiment;
1 lb. of potash made caustic with lime.

Dissolve the potash in the water at a boiling heat, and add to the solution half a pound of quicklime in powder; boil and stir occasionally, for several hours; then let the sediment subside; draw off the clear liquor; make it up to one gallon, by the addition of water; then add the orpiment, and dissolve at a boiling heat: when dissolved, let the sediment (for there will always be more or less insoluble matter in the orpiment) fall to the bottom; decant the clear liquor; add the indigo, and stir till dissolved. Thicken the clear solution with gum Senegal, or British gum; if with the former, while it is yet hot; if with the latter, after it has become cold. This colour is printed either with the pencil, the cylinder, or with the block from the spring sieve.

Owing to the strong tendency of this indigo to attract oxygen from the atmosphere, this colour must be kept carefully excluded, as far as possible, from contact with the air. Some

printers thicken pencil blue with glue, when worked by the block.

The changes which take place in this process, are very similar to those which occur in the blue vat; and, as it regards the indigo, there is no difference; the sulphur and arsenic of the orpiment both attract oxygen from the indigo: the former becomes converted into sulphuric acid, and the latter into an oxide, and both uniting, form a sulphate of arsenic, while the indigo, reduced to its green state, becomes soluble in the alkali. So strong is the attraction of this mixture for oxygen, that its surface rapidly combines with it when exposed to the air; and, as the indigo is, in that state, insoluble, it is extremely difficult to print a figure by the block, which shall have a uniform shade, or an even *boundage*. On this account, it is always bounded, in chintz patterns, where alone it is applied by the block, by some dark colour, and, in general, by black previously printed, which gives to the blue figure the appearance of a defined margin, and disguises the unevenness of the colour. The orpiment, or rather the new compound which it forms, is washed away in the dash wheel. This colour by no means equals the China blue in depth, or beauty. The concentrated solution of potash necessarily employed in its preparation, is supposed to impair the colour of the indigo. The proportion of orpiment directed is rather larger than is required to deoxidize the indigo in the first instance, and larger considerably than many printers employ, but, as the solution has a constant tendency to attract oxygen, from the least exposure to the air, and, as some parts of the indigo require the deoxidizing process to be repeated again and again, an excess of orpiment is advisable.

The foregoing is as concentrated a solution as will often be wanted, but it may be made more, or less so, according to the shade required. The solution, when agitated, should exhibit a rich greenish yellow colour, and its surface become quickly covered with blue and purple veins; in short, it is a blue vat in miniature, both in principle and appearance.

Warwick's Green.

A permanent topical green was, for a long time, a desideratum with calico printers.* The common aluminous mordant, and the pencil blue above described, it is obvious, would be incompatible compounds, as the moment they were mixed, the acids of the mordant would combine with the potash of the pen-

* The object was to combine the aluminous base, in a soluble state, with deoxidized indigo, and to apply them cotemporaneously to the cloth, and afterwards dye in the quercitron bark.

oil blue, and both the indigo and the alumine would be precipitated from their solutions in an insoluble state. The discovery of the alkaline solution of alumine solved this difficult problem in the art. To prepare this colour, dissolve in one gallon of the alkaline solution of alumine, (which see) at a boiling heat (of water) one pound of ground indigo, in the form of a paste, containing one quart of water, and three-fourths of a pound of red, or orange orpiment. When cold, thicken the liquor with *high* dried British gum, three or four pounds to the gallon, if for the cylinder; but with less, if for the spring sieve. Fix the mordant as directed for the alkaline solution, and dye in quercitron bark, as for yellows. The public is indebted for the method of preparing the alkaline solution of alumine to James Thomson, Esq., a celebrated calico printer, in Lancashire, and to Dr. T. O. Warwick, an ingenious manufacturing chemist of Manchester, for the method of fixing it. To both of these gentlemen the trade are under great obligations for numerous improvements in the art.*

London Green.

To one gallon of caustic potash ley, at 40° T., add two pounds of crystallized muriate of tin, and fourteen ounces of indigo in fine powder; mix, raise slowly to a boil, and stir occasionally during the solution. As soon as the liquor boils, remove it from the fire, and when cold, add as much muriatic acid as will be necessary to saturate the alkali and redissolve the oxide of tin. Then dissolve in the mixture twelve ounces of alum, and thicken with gum Senegal.

The solution of tin and indigo may be kept for any length of time in a closed vessel; but when the acid is added, it must be used the same day. Print with the block; this colour will not work on the cylinder. If a *brassed* block be used, care must be taken that it be cleaned, before using, from verdigris, otherwise the colour will be injured. This colour is designed for working on a common teering sieve.

When printed, and dry, dip the cloth for two or three minutes in a lime vat; wash well; expose to the air till the green has gone off, and then dye in quercitron bark as in Warwick's green.

In this process the indigo is deoxidized by the protoxide of tin, and both are dissolved in the alkaline solution. The muriatic acid saturates the alkali, forming a muriate of potash, re-

* Dr. Ure, in a note to the first volume of his Translation of Berthollet's "Elements of Dyeing, &c." has, unintentionally, done injustice to Dr. Warwick, by ascribing the whole merit of this valuable colour to Mr. Thomson.

dissolves the tin, forming a permuriate of tin, and, affording no oxygen, precipitates the indigo in its green state; the alum is added as the mordant for the yellow of the bark, and, together with the muriates of tin and potash, is mixed up into a paste with gum. In the fixing process, the lime decomposes the muriate and sulphate, precipitates the alumine, and so far dissolves the indigo as to enable it to combine with the cloth.

Some of the Lancashire printers have produced very good work with this colour, but it requires very careful management, and, on the whole, is scarcely to be preferred, even for the block, to Warwick's green. The indigo of the paste being in the solid state, it will not work with the engraved cylinder.

Having described and explained the principal processes in calico printing, in their simplest forms, it remains to say something of the combination and order of these processes in what are denominated styles of printing, where several colours are produced on the same piece. I have partly anticipated this subject in several parts of this treatise, and particularly in speaking of the discharges printed on padded grounds, to which I have nothing more to add here. In the printing of *steam* and *spirit* colours, also, nothing more need be said; for, with the exception of the mixing the colours, the process is the same in these styles, whether one or ten colours are produced on the same pattern: the colours are all printed in succession, and raised by one and the same operation. It matters not which are applied first,* nor is there any such thing as chemical incompatibility among them; all the colours known in these styles may be produced on the same piece.

The circumstances are very different in printing fast colours where the calico is usually wet after the application of each colour, or each class of colours, and where each colour or class of colours has its peculiar dye or raising liquor; here the observance of a certain order in the processes is indispensable, as otherwise the effect may be to destroy, by each operation, the colours which were raised or dyed by a previous one.

The general rule is to print and dye those colours first which will be least affected by the subsequent dyeing, or raising processes, and to print as many colours before each dyeing or

* At least the only circumstance that must determine the order of the application of the different colours, is the mechanical convenience of the printer; it is usual to print those colours last which cover the most surface, as otherwise the drying of large figures in paste is liable to crumple the cloth, and render the application of after colours more difficult.

raising as can be dyed or raised in the same liquor. To make this subject more intelligible to the learner, and to give him a general view of the order and connexion of the processes in printing fast colours, I will subjoin the following description of several styles of work, which, together with those already described in different parts of this treatise, comprise the most important combinations in the art.

A Full Chintz, on a White Ground.

The colours in this style are three shades of red, a black, two or more shades of purple, yellow, drab, olive, blue, green, and buff. Now, as the reds, blacks, and purples may all be dyed in the madder bath, and when produced are not much affected by the processes for raising or dyeing the other colours, the mordants for these colours are first printed and dyed, the directions for which have already been given under the head of madder dyeing. These cloths being smoothly callendered or mangled before the application of these first colours, they are printed with the widest and largest blocks. After dyeing and drying, the cloth is again callendered, printed with the mordants for the yellow and drab colours, and dyed in quercitron bark. The figures dyed in bark are usually designed to fit and correspond accurately with those previously dyed in madder; but, as the cloth becomes stretched in the operations of dyeing and drying, the printing of these mordants, and, indeed, of all subsequent ones, is more difficult, and is necessarily done with narrower blocks. These after printings are called in the art *grounding*, *half-blocking*, or *printing off the grass*; the last term is derived from the circumstance, that formerly, after madder dyeing, (as well, indeed, as after other processes,) the goods were exposed to the action of sun and air in clearing the white grounds, a practice which is now nearly exploded by the introduction of the compounds of chlorine for this purpose. The exact width and length of the blocks, both for this and previous printings, are within certain limits determined wholly by the character of the pattern; if the joinings and adaptations be difficult, the block must be proportionally small, and *vice versa*.

The olive colour is generally produced by the drab falling on the mordant for the yellow. The shade of olive will be deeper, if from one to four ounces of Sicily sumach be added to the dyeing in bark; but to produce a dark olive in this way, it is absolutely necessary that the yellow be printed and dyed first, and the drab afterwards; otherwise, such is the superior strength of the aluminous mordant for the colouring matter of the bark, that a great proportion of the iron mordant will be dissolved away before any part of the colouring matter of the bark is at-

tracted by it, and fixed upon the cloth. Some printers trust to obviate this difficulty by printing, ageing, and dunging the drab before printing the yellow mordant, but this is attended with nearly the same expense as two separate dyeings in bark, and never fully answers the purpose.

If the foregoing order of the processes had been reversed, and the mordants for the colours dyed in-quercitron bark, printed and dyed before those of the madder, the result would have been very different: the madder colours last dyed would have been the same, but the yellow of the bark would have been changed from a red to a deep orange, the drab to a dirty purple, and the olive to a chocolate. This is owing to the superior attraction of madder for the mordants, which is such as to displace, under these circumstances, the colouring matter of the bark already combined with the mordant, and to enter into combination with it, to its (the colouring matter of the bark) almost entire exclusion. Hence, when colours are to be dyed both from madder and quercitron bark, the dyeing in the former must always precede the latter.

The buff may be next printed, and raised in the manner directed under this head. It is obvious that this colour could not precede or accompany the dyeings in madder or bark, as it would in either case have constituted a mordant, and dyed up a black or purple with the former, and a dark olive or drab with the latter. If any part of the buff colour fall, in printing upon the madder reds, it will change them to a chocolate; if it fall upon the yellow, it will change it to an olive: but these shades will be much darker if the madder and the bark colours have been dyed with a little sumach, from two to four ounces to the piece, according to the strength of the pattern.

The pencil blue is usually printed either along with the madder colours, or the last of all; in the former case the colour is applied with a whole block, and at about half the expense, but the blue is never so bright after passing through the madder and bark dyes.

The green is produced by the blue falling on the yellow, or *vice versa*.

Since the introduction of machine printing, the strong red and black of the foregoing style are more commonly printed by the engraved roller instead of blocks; but this variation causes no difference in the general conduct and principles of the operations described.

A Black, Resisting Red, and Green, on a Blue Ground.

Print the black first, (generally with the machine,) and, if any considerable part of the red cover the black figure, dye up the

black after suitable age and dunging, and the grounds are cleared; print a strong resisting red with half blocks, and dip in the blue vat; cleanse, dry, and print the aluminous mordant on a portion of the blue ground, and dye in bark. If the red figure do not cover much of the black, the resisting red may be printed with whole blocks before the black is dyed up, and both dyed up together after dipping. The reason for these directions, with respect to the dyeing of the black and red, are, that it is impossible to obtain even a tolerable black where a red is printed over it before dyeing, as the aluminous mordant will always divide with the iron the colouring matter of the dye, and a chocolate, and not a black, is the result.

A Black, Resisting Red, Green, Yellow, and White, on a Blue Ground.

This style is the same as the last to the printing of the resist red; the white is produced by printing a *mild paste* before dipping, which resists as well as the resisting red the action of the blue vat on the part so printed; after dipping, and dyeing in madder, the calico is printed again for a yellow, and dyed in quercitron bark; that portion of the yellow mordant which falls on the blue produces a green; that which falls on the white, a yellow. The last blocking is not unfrequently omitted when we have merely a black, red, blue, and white.

If a pale instead of a strong resist red be printed in the above style, a bright orange may be produced by the yellow mordant's falling upon a part of it, and thereby give an additional colour.

A Black, Plum, Resist Yellow, and Orange, on a Blue Ground.

Print for a black, (usually with the machine,) and in pale red with the block; dye in madder, and then print a resisting yellow paste, so that a part of it shall fall upon the white ground and a part upon the pale red; dip pale blue, and dye in quercitron bark. The pale or sky blue falling upon the pale red, produces a plum, or what the printers call a bloom colour. That part of the resisting yellow, which falls upon and protects a portion of the pale red, produces an orange of a deeper or lighter shade, according to the shade of red in the first instance. The shade of plum, or bloom, will also vary with the particular strength or depth of the pale red and blue, by which it is formed. A characteristic of this style is, that it can have no green in it, although it contains a yellow.

A Black, Red, Yellow, Green, and White, on a Blue Ground.

The colours in this style are the same as in the last mentioned but one, but it is a far more difficult and more beautiful style. Print (with the two coloured machine if convenient) a mordant for a black and a *neutral paste*; then print, by the block, a strong resisting red, so that a part of it shall fall upon the white ground, and a part upon the neutral paste; dip for a sky blue; dye up in madder, and then block for a yellow, so that a part of the mordant may fall upon the white figures, produced by the neutral paste, and a part on the blue ground, and dye in quercitron bark. The great beauty of the style is the sharpness and delicacy of the figure caused by the neutral paste, which cuts indiscriminately through both the indigo blue and the resisting red. If the resisting red be required to cover any part of the black, this colour must be dyed up first, and the resisting red and neutral paste printed with half blocks; at least, nothing deeper than a dark chocolate can be obtained, if the red and black mordant be dyed up at the same time. If a chocolate be printed by the block instead of a resisting red, the black may be wholly omitted, and a very pretty style obtained.

A Chocolate and Buff, on a Blue Ground.

Print for a madder chocolate, and dye up; then half block in resist buff, and dip for the shade of blue. The lime of the vat will be found sufficient for raising the buff, and nothing more is required than simply washing and cleansing after the dip; but, for the particular management of this part of the process, see "Resist Buff."

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